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THE
Psychological Monographs

The Psychology of Clothing

BY

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To

F. E. F.

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"Clothes too, which began in foolishest love of Ornament, what have they not become! Increased Security and pleasurable Heat soon followed: but what of these? Shame, divine Shame (*Schaam,* Modesty), as yet a stranger to the Anthropophagous bosom, arose there mysteriously under Clothes; a mystic grove-encircled shrine for the Holy in man. Clothes gave us individuality, distinctions, social polity; Clothes have made men of us; they are threatening to make Clothes-screens of us."

"For neither in tailoring nor in legislating does man proceed by mere Accident, but the hand is ever guided on by the mysterious operations of the mind. In all his Modes, and habilitory endeavours, an Architectural Idea will be found lurking; his Body and the Cloth are the site and materials whereon and whereby his beautiful edifice, of a Person, is to be built. Whether he flow gracefully out in folded mantles, based on light sandals; tower up in high headgear, from amid peaks, spangles and bell-girdles; swell out in starched ruffs, buckram stuffings, and monstrous tuberosities; or girth himself into separate sections, and front the world an Agglomeration of four limbs,—will depend on the nature of such Architectural Idea: whether Grecian, Gothic, Later-Gothic, or altogether modern, and Parisian or Anglo-Dandiacal. Again, what meaning lies in Color! From the soberest drab to the high-flaming scarlet, spiritual idiosyncracies unfold themselves in choice of Color: if the Cut betoken Intellect and Talent, so does the Color betoken Temper and Heart. In all which, among nations as among individuals, there is an incessant, indubitable though infinitely complex working of Cause and Effect: every snip of the Scissors has been regulated and prescribed by ever-active influences, which doubtless to Intelligences of a superior order are neither invisible nor illegible." (Thomas Carlyle: *"Sartor Resartus,"* I, V, 1830.)

The present discussion, a kind of scientific ghost of "Sartor Resartus," developed as lectures in the Fruhauf School of Salesmanship in New York in August, 1917.

I. INTRODUCTION

The science of clothing so far has never been developed; it is something new, almost pioneer scientific work. The personal science of clothes and of being clothed, then, is the topic on which I would suggest a few considerations from a somewhat technical point of view.

It includes, as I shall consider it, two phases, first, a physiological psychology of clothing, and then the beginnings of the applied psychology of clothing. These complement each other. All this is a new application of psychology (the general science of how to live), and one of which the great public is much in real need. The public, to be sure, does not realize this need, any more than it knew that it was in pressing need of information on diet or on sex or on other things. The public does need basic scientific information on how to clothe themselves properly so that they will be both more efficient and more happy, because continually more comfortable.

1. *The Satisfaction-Efficiency Ratio.*—Underlying this whole matter of the physiology and the psychology of clothing is an ancient idea which is of fundamental importance throughout the whole matter. In the lectures to my students I give it the technical name of the sthen-euphoric index or ratio,—but we wont worry about the name. Sthen and euphor are two Greek terms; sthen stands for strength or energy, and euphor for well-bearing, contentment, well-being, happiness; while ratio, of course, or "index," is the relationship between the other two. The old and simple-enough idea then, is, to put it wholly outside of scientific terms, that one expends more energy and is therefore more efficient in many ways when he is contented and happy, using the word happy as a symbol for the broad translation of the general Greek term euphoria. When a person is satisfied, contented, in good humor, when he is "happy," in short, he expends more energy, has more initiative, and is altogether more efficient than when he is unhappy, worrying about something, or when he

"has a grouch," or any other of the conditions opposite to happiness. *Freedom from discomfort* underlies it. It importantly underlies the psychology of clothing in particular, without any doubt at all, because personal comfort is absolutely essential "in the long run" to a high-grade of efficiency in the long life-run. This is not so much true of an Eastport man for example feeding sheets of tin to a sardine-box stamping machine, but it is true of any kind of work which involves the optimum action of the "higher" and freer phases of the mind and skilled body. Comfort in general is indispensable to ideal behaviour that is at all free.

Comfort has both a physiological and a psychological aspect; but both aspects underlie efficiency in a way which is measurable even in dollars and cents. The factory-managers, as you already are aware, not many years ago started out to prompt their employees and operatives to maintain better health, to keep them in better "condition"; finding that it was a "good policy," even as income was concerned, to go so far as to hire a "doctor" at two or three thousand a year to help keep the employees well.

The next inevitable step will be to apply exactly the same principle to keeping them personally contented and "happy." That's the next economic step, and a friend of mine at Harvard and myself hope to make some observations after the war, on that matter, with the intent to see if a child in school who is "happy" does not do better learning-work than one who is uncomfortable or unhappy; to see, too, if a girl working in a paper-box factory does not make more boxes in the course of a week when she is "happy" than she makes when she is wretched, unhappy, discontented.

There is a scientific basis underlying this notion that happiness is related to a large expenditure of energy and to a high mental efficiency; and the higher the grade of the activity, the freer the mental work, the truer it certainly is. The fine-artists have been showing us that all along. Poets, musicians, painters, sculptors often refuse to work when they "don't feel like work," and they have always found by experience that only thus can they make their highest grade of achievement.

I say comfort then is a matter both of passing life-enjoyment and of dollars and cents,—and the latter is perhaps the best, because the ultimate, materialistic index and way of suggesting the practical phases of the subject. The two are interdependent very intimately, and related "in the long run" so that they cannot be separated.

2. *A General Public Need*

The present discussion concerns first the physiological psychology of clothes. My approach in this knowledge is mostly that of pure science from the universities and from the psychological and physiological laboratories, although no actual researches that I am able to hear of have as yet been done in a scientific laboratory on the psychology of clothing. There have been some questionary observations made, (at Clark and, I have heard, at Columbia), they have asked young people questions, but no psychological laboratory, so far as I am aware, has ever taken up the widely interesting matter experimentally. It is a matter of some difficulty, and much expense and apparatus. (A university professor wrote me recently that he had been intending for some years to attack the problem, but that the difficulty of it and his lack of time had so far kept him from it.)

I offer you the scientific base-facts so far as I can get them, to be used as you please, hoping some time to be able to start in one way or another some actual relevant psychological experiments. It is a matter that can be experimented on and reduced to more or less exact figures, so that the conclusions are certain, rather than vaguer corollaries from certain scientific principles.

If ten per cent be a moderate estimate of the present inefficiency arising from maladapted clothing, it is obvious that adequate endowment for the scientific study of human raiment is a public need,—a need not as yet widely realized, perhaps because never before scientifically defined. We shall do at least that much!

II. PHYSIOLOGIC PSYCHOLOGY

There is much more physiology in the science of adequate clothing as a process than most men, even the physiologists, would at first suspect. And yet it is obvious, on thought for a moment, that any covering as heavy, as complete, and as relatively rigid as an average suit of clothes or a proper gown could not help having multiform influences within and without over the body which wears it. Because so universal and so continuous, these influences are of noteworthy scientific and practical importance.

The reason in a nutshell for this is that one's clothes are one of the important things that intervenes between the individual personality and his environment, and you understand that life itself in a sense is a reaction of an individual to his environment. As Webb puts it, "As a matter of fact, our artificial coverings have become so much a part of our life that one may perhaps be allowed to apply the methods of the naturalist to their consideration, and deal with them as if they were part and parcel of the creature which wears them"—as pragmatically they are. We might almost consider clothes as a vicarious or artificial skin, almost an extension of the individual's boundary, involving important relationships between the person and his environment, spiritual as much as material. And that is the reason, the deeply fundamental reason, why there is so much real science in the physiology and the psychology of clothing, subjective and objective, personally and socially and industrially.

Let us take up first then the discussion of the physiological psychology of clothes in three groups of relations: 1, to the skin; 2, to bodily action or behavior; and 3, to body-temperature.

Since the centuries,—those slow, groping, aspiring centuries!—when manhood and womanhood were new and our preprogenitors were covered with a fairly thick mantle of hair, the human animal man has been a naturally *naked* creature. He naturally is so, still. For a reason none too easily apprehended, there seems to us something ludicrous in this nakedness of the naîve savage. Thomas Hood the Younger, for example, almost blushes as he tells us

"And their principle clothes were a ring through the nose
And a patch of red paint on the forehead,"

while other poetasters less known to fame than Thomas Hood, and escaped missionaries and cartoonists innumerable have almost vied with each other in expressing in memorable phrases the insistent natural nakedness, always adorned, of natural man. This interesting and important negative phase of our subject we must for the present all but ignore.

The human animal is naturally, if you please, then, and normally a naked animal, and up to within about three hundred years ago people were allowed to live in corners of Europe, specially in Ireland and in Germany (Rudeck), naked. Up to three centuries ago, at least, the nakedness of the primeval man had not become so entirely "immodest" that it was prohibited by enforced law. Man is naturally a naked animal, and it takes a very long time indeed to adapt an organism to artificial, "acquired" new conditions. Furless and with little hair was primeval man; and he still likes to be so.

In clothing him, therefore, one has to respect and not ignore this natural nakedness; and especially the basal fact that man gets his highest comfort when naturally warm environmental air is freely playing over and on his skin. You all know, of course, the delight of exposure to the breeze, and to warm showers, and to other conditions of the natural environment, when you are naked.

Now, this basic principle of the physiology of clothes, (that man is constructed for efficiency-with-happiness, primally as a *naked* animal) requires that he be rather careful in adapting ideal clothing to his requirements, because man, after all, is a highly sensitive being. His efficiency is an intricate and a rather susceptible thing, and has to be catered to, if he is to get the most out of his few and flying years.

1. *Relations of Clothing to the Skin.*

I have briefly described in my Text-Book of Human Physiology, (pp. 312-326) published ten years ago, nine functions of the skin. I am not going greatly to bore you with these nine functions, because they are too physiologically technical, but there are some of these nine functions which are important for our particular purpose in studying the science of being clothed. The nine are: protection; the regulation of body temperature; sensation of various kinds; the excretion of sweat; the secretion of sebum, (which is the oil of the skin and hair); respiration; the absorption of certain things; coloration of the skin, (which add to the individual's beauty and protect him from undue light), and, technically, support of the hairs and nails.

A. *Protection* of the body by the skin is served largely by the outer portion termed the epidermis. It is 0.1 millimeter in thickness and consists of many layers of stratified epithelium, the outermost of which, called the stratum corneum, consists of horny, non-nucleated squames, the layers nearest the surface being practically dead and dry. As the lower layers of the epidermis develop, the outer layers are shed by maceration in bathing and by friction. This highly fabricated structure of the outer portion of the skin is one eminently adapted to protecion of the highly sensitive body, beneath it in at least the following respects:

(a) It is a bad conductor of heat; (b) It is mobile on the tissues beneath it and so a minimizer of friction from a more or less harmful environment. (c) It is free of nerves, and so insensitive in itself. (d) It is flexible and yet hard and resistant because made up of scales. (e) It is extensible and so readily adaptable to the temporary variations in the size of parts beneath it. (f) The skin is in many places a soft and elastic pad, thus preventing irritating jars (e.g., on the heel). (g) For the same reason it often prevents pressure on delicate parts beneath. (h) Because dead, the epidermis prevents parts (e.g., the toes) from growing together. (i) The skin by its oiliness prevents undue maceration of the body when in water and very moist air. (j) The epidermis dry is an excellent non-conductor of electricity. (k) Its keratinous composition makes it resistent to many chemicals.

B. *Excretion of Sweat* is, next to protection, the skin's most important function. Sweat is a clear liquid of a specific gravity of 1004, either alkaline or acid in reaction. Average daily amount is about fifteen hundred cubic centimeters, it being evaporated continually into the atmosphere. Sweat when visible is termed "sensible," when invisible "insensible" perspiration, the latter being by far the more important.

The composition of sweat has been determined variously, 1.2 per cent is solid, and of this, three-quarters are "organic" including neutral fats, cholesterin, fatty acids, proteid, 0.1 per cent of urea, pigment, sodium and potassium chloride, phosphates, uric acid, skatol, phenol, creatinin, carbon dioxide, and a little nitrogen.

The secretion of sweat is determined by: a, Temperature of environment; b, Activity of heart; c, Vascular tone; d, Muscular activity; e, Fluidity of blood; f, Relative activity of kidneys and rectum; g, Ingestion of certain drugs; h, Nervous system.

The sweat-centers seem to be located in the medulla oblongata, with subsidiary centers up and down the cord, perhaps.

The chief function of sweat is to excrete half the ingested water, thus controlling body-heat to a large extent, evaporation and radiation being, of course, cooling processes. Soluble salts, especially urea, are also excreted by the skin, often in visible amounts.

C. *Secretion of Sebum* is the work of a set of glands in the skin, the sebaceous glands. Their ducts empty into the hair-follicles. The cerumen or wax of the external ear, and the secretion of the Meibomian glands on the eyelids' edges are both modified sebum, whose uses are obvious; and there are others.

The *function of sebum* is to soften with its fats the epidermis and hairs and to keep the skin impervious to water.

D. *Regulation of the body-temperature,* (to a considerable extent) is brought about by the skin through its position at the periphery of the body, where loss of heat by radiation conduction, and by evaporation of water, would naturally take place. Four conditions at least, control the storage and loss of body-heat so far as the skin is concerned:

(a) The amount of blood passing through the dermal capillaries helps to determine the amount of heat-loss because the loss takes place by radiation and conduction of the heat brought from within the blood, and by the evaporation of the sweat, dependent largely on the dermal blood-flow. Hence.

(b) The amount of sweat excreted has much to do with heat-loss (thermolysis) and heat storage, evaporation being greater when sweat is greater in amount.

(c) The relative oiliness of the skin determines to some extent heat-loss, because an oily skin is very much better conductor of heat than is a dry skin. Radiation and conduction of heat would be greater when the skin is secreting much sebum.

(d) The humidity and temperature of the atmosphere are important factors in thermolysis and heat-storage, for radiation and conduction would be greater on a cold, damp day, than on a dry, warm day. Evaporation, on the other hand, would of course, be less on the damp, cold day, while on the dry, cold days, other combinations would obtain between radiation and evaporation. Thus in the dermal capillary circulation and in the sweat-glands there is a possible means of great delicacy and adaptability of regulating body heat. How elaborate the actual mechanism may be, we do not know.

E. *Respiration,* is conducted by the skin, but on a very small scale, only a few grams of oxygen passing into the blood and a few grams of carbonic dioxide passing thence into the air, in twenty-four hours. The dermal respiration is certainly not one per cent of that through the lungs, but is more prominent when the lungs fail to do their work, a "vicarious function."

F. *Sensation* is certainly a very important function of the skin, for thereby only to a large extent can the animal adapt itself to its complex and everchanging environment.

The skin is the site of neural end-organs of (a) touch, (b) pressure, (c) heat, (b) cold, and probably also of (e) pain, and of (f) pleasure, with a possibility rather remote that (g) tickle, (h) moisture and (i) electricity are also made known to us through dermal sense-organs. Considering the complexity of our minds, the presumption always is in favor of a greater variety of sense-organs than we now can positively describe, although a dozen are now known.

G. *Absorption* through the skin is slight save of fatty substances when placed upon it or rubbed into it, and of such substances as may be actually dissolved in this fat. We have seen above that a little oxygen and carbonic dioxide also pass in and out through the skin. Water apparently does not to any great extent.

H. *Coloration* in the human animal is useful in giving beauty to the body, thus adding a factor to sexual selection. In some of the lower animals, e.g., fishes, frogs, and insects, great protection from devouring enemies is afforded by the adapted deposition of pigment so the better imitating the animal's environment. Pigment protects against too much light: tan and freckles.

I. *Support of the hairs,* etc., which grow in nearly all parts of the body, is the last of the dermal functions we mention. The support is both mechanical and chemical, for the skin furnishes oil and moisture to the hairs. Explanation of the presence of the hair in man must be sought in evolution, partly as a survival of the necessary protection from cold in case of the brutes, the growth on the head, and on the face in men, serving the same function for humanity. Their esthetic value also should not be overlooked. The lanugo hairs scattered over most parts of the body are the most sensitive of all organs of touch, each having about it within its sheath a ring (Bonnet's) of nerve-fibrils. This may be considered as their most important function, but they help to protect the brain.

The *nails* also are dermal appendages of quite essential value in human behavior.

Of these nine dermal functions, protection, the regulation of body-temperature, the sensations of various kinds,* sweat-evaporation, and breathing are five which have fundamental relations to the science of clothing.

A, Let us consider first that *the clothes must not irritate the skin,*—briefly statable, but of quite primary importance. There are sense organs everywhere in the skin in multitudes, and obviously clothes which irritate, (a scratchy linen collar, for example, or a coat-collar which comes habitually against the back of the neck, poisonous hosiery-dye, or a projecting heel-nail), is an extreme cause of irritation not only to the skin, but through the integrating nervous system to the entire individual.

B, Breathing must be allowed by the clothes. Only about half of one per cent of the respiratory exchange really goes on through the human skin. We are not like frogs, which breathe half through their integument and so satisfactorily that they can spend a winter buried deep in the mud at the bottom of a pond, of course meanwhile living perfectly well because they can breathe adequately through the efficient moist skin. It isn't then that the human integument in itself is an important organ of respiration; but it is that it serves importantly as the receptor reflexion-organ, probably, for the control of the respiratory movements in, and possibly of, the lungs. The physiologist Bohr (unfortunately he recently died, and before he had a chance to

*See Smith Ely Jelliffe: "The Dermal and the General Sensations" in Moffat, Yard & Co's. *Our Senses Series,* to be continued after the war.

demonstrate) worked out the very probable concern of the skin in the ventilation of the lungs. It is important, then, that the skin by being wrongly clothed should not be deprived of part of its natural function of somewhat regulating the respiratory process, so that this reflexion is prevented, and the important friction of air, and even of the cloth on the skin thwarted by clothes generally too tight or too impervious or both.

The present writer already had made some suggestions in this line in the Psychological Review of May, 1914. We may repeat two paragraphs:

The second process (the first is sweating) which appears to actuate dermal receptors so as to effect an euphoric tone in the individual's consciousness (not to say in his subconsciousness) is oxidation, one of metabolism's foundation-stones. Experiments done long ago seemed to show that so far as the body's respiration is concerned only about 0.5 per cent occurs directly through the skin. But this small fraction shows that oxidative processes do occur in the skin. When one considers the minuteness of the various dermal receptors and their possibilities of actuation by the "circumambient air," together with physiologic data immediately to be noted, the reasonableness of supposing dermal oxidation to be a factor of euphoria is readily admitted. Bohr showed that ventilation of the blood in the lungs is probably a reflex process of active secretion by the alveolar epithelium. Y. Henderson on the other hand, while admitting the oxidative secretion, supposes that the depression of "mugginess" comes from the kolionic inhibition of this secretion in the lungs. The receptors of this reflex oxidation, it is possible or rather more, are in the skin, and may be found to be one of the varieties of end-organ mentioned considerably above. Graham Lusk showed by experiments in which men were emersed in water at 10° C. for from seven or eight to twelve minutes that the metabolism increased 181 per cent.—and respiration is always the metabolic index. The experimenter ascribed the increase to the men's shivering, but it seems possible at least in the light of Bohr's work that the increased activity of alveolar secretion of oxygen into the blood may have something to do with the heightened oxidation.

This supposition seems strengthened by late work of Max Verworn which demonstrates, among other important things, the immediate dependence of the action of the nervous system on oxygen,—an extension of his much earlier proof that ameba stops flowing in about an hour when oxygen is removed from its environment. Without ideal speculation as to the affective tones of ameba (!), it is fairly rational to presume that some or all of the delicately complex receptors in the human skin, close to the air as they are, may have their activity and their consequent streams of neurokinesis increased by exposure to moving air as contrasted with air that is dead. It is my present hypothesis, then, that moving air in some way has a tonic action on the afferent influences from the skin by stimulation of whichever receptors in that very complex receptive field are tuned to this mode of energy. The mere presence of oxygen is not enough for a normal euphoria—it actuates, perhaps by way of the pulmonary epithelium, only when coming as a moving force (with friction perhaps) against or over the skin. If, however, friction be really an element in dermal cenesthesia, it is probably not the gross mechanic friction one is apt to think of first, but rather a subtle sort of physiologic friction, so to say, adapted to the extreme delicacy of the organic instruments so abundant in the human skin. On the other hand, the mysterious highly euphoric stimulation of a gale of wind when not outside the optimum range of temperature (as in the splendid Nova Scotian summerland in September) is known to all, and this implies that gross friction, friction in the ordinary physical sense of the term, may be also a factor in the experienced product. Massage and the caress seem to possibly imply the same thing.

This is part of the psychophysiology of the future, these complex but all-important recondite functions of the skin. At the present time, it is plain that the skin is *an organ* proper, with its own work of great importance to do; but it is equally plain that the skin of man is also a highly intricate and all-important *receptive field*, with receptors that serve to relate the individual with his always complex effective environment. Respiration seems likely to prove part of this wide integration of vital functions.

The euphoric, or comfort-, factors of the skin, set forth already in the article from which we have just repeated, we may not take space further to discuss. But it must be noted that they are *important* both for efficiency and in themselves; and that clothing is a closely related theme for applied science to study.

It is close at hand that one's clothing must be fabricated on the general principles which are of importance in all of these recondite dermal and organic affairs. But here we may only hint at some of the most obvious conditions.

Here comes in first, of course, texture, whether open or tight. A free movement of the air on the skin is of fundamental importance. Or this may be secured by a general looseness of the clothing. Our wiser English cousins have practiced this for long. It appeals to me scientifically as well as personally very strongly that clothing both hygenically and for comfort should be *loose,* and thus allow of a slight circulation of air, so to say, off and on, underneath it over the body clad beneath in our intricate and sensitive skin.

C, Various kinds of *protection* are served by our clothing; clothes protect us from many different kinds of things. I am going to spend some time later on going into some of the details of the psychological protection; but there are sundry physiological protections offered by raiment that we may mention now. From cold, for example; on the other hand, the day-laborer digging trenches in the street in over-hot weather knows by hearsay and by experience that two or three thick woolen undershirts then will keep him cool as well as they will keep him warm in winter, in July keeping the heat out as in January this clothing will keep it in.

Proper clothes protect the person from sunburn too; from some insects; from various mechanical impacts. And, more important by far than these mechanical influences, clothes afford protection from various mental things, which I will make a business of suggesting and briefly discussing in the third section of the monograph.

On a very rough estimate, every adult evaporates probably at least five liters of sweat during each sultry summer day. I have in my notes a scientific report of hand blowers in a glass-factory who averaged a daily excretion of twenty-three pints of sweat, and work would have been impossible quite without the cooling produced by this ample vicarious evaporation. One can see that the sweating-process is a very important one, and hence one not to be impeded by inadequate clothes, day or night.

2, *Relations to Bodily Action.* The second general habilatory notion that I would suggest, is the need of freedom for bodily action. As we shall see, this is not only related to the actual material movements of the body itself, but underlies also the higher efficiency of the mind as well as of the body,—the two indeed being aspects of one thing, the actual living personality; of us, in short, who wear the clothes.

One of the things that has been quite ignored in thinking of clothes-comfort and hygiene is the set of sensations of the interior of the body ("coenesthesia") and of the muscles, tendons, and the joints, technically called kinesthesia, ("the feeling of movement"), but, more commonly, still termed the muscle-joint sense. The viscera, the muscles, the tendons, the joints, the skin, and the bones are continually giving to the brain and into the mind a multitude of sensations that represent the various strains and the various movements and restraints of each of the parts of the body.*

In the science of clothing these coenesthetic and *kinesthetic* data are of preëminent importance. Unless these movements are unrestrained and free, unless these conscious and subconscious sensations are kept from being restricted and therefore made unpleasant, the individual is not comfortable and cannot be fully efficient or consciously "happy," but there is a more or less conscious lack of freedom and of satisfaction. The naturally naked man feels none of this unpleasant restraint.

If clothing fits, it interferes little with our life-activities, and "fit" means fit the one particular body that it is made or intended for. Everybody and also the actions of everybody are characteristically different from those of every other body. Each individual is unique, has a personality of his own. Please ob-

* See the volume on these sensations, on the sense of "feeling," in the "Our Senses Series," already cited.

serve that he has not only a body of his own, not only a material body to be fitted with clothing, but a group of actions to be fitted. It is my small experience that the average tailor pays far too little attention to the fittable body in its action-aspect. A really well-fitting suit of clothes or a gown fits the body as that particular body actually *works* in the course of a day and night. It doesn't fit it as it is quietly standing up on a stool, but fits it as the habitual continual movements of that particular individual require it to be fitted.

Fit involves at least five kinds of freedom, freedom of the body primarily, but in both its reflex and voluntary aspects.

A, Digestive actions. The relations of clothes to the digestive organs is obvious to many people about or after middle life, (thirty-five) but seldom are noticed by those who are younger. The stomach and the transverse colon, it must be remembered, are conspicuous in front just above the top of a man's trousers and about the middle part of his waistcoat, vest. When the stomach is tender from neuritis, ulcer, mild inflamation or worse, or when the transverse colon, as it often is, grossly overloaded, it is obvious that clothing too tight around this region would have a very disturbing, although at first often subconscious, influence on the person's general comfort. Often too, as we know now better and better, very frequently the stomach is dilated from habitual distension from too fast and over-eating, and this adds a similar, but more acute element, to this disturbing influence at the waist. It is very likely that man's curious but confirmed habit of standing on his hind legs has much to do with the etiology of ptosis of the stomach,—as surely it has to do with his clothing.

B, Breathing movements. It need not be pointed out in this place that practically the entire body is disturbed or very actively concerned in even the ordinary movements of respiration. The abdominal influences affect the entire abdomen, the abdominal walls being pushed forward and sidewise, and all the viscera more or less displaced. Many of the muscles of the abdominal wall and of the thorax are actively concerned in the process of expiration, especially.

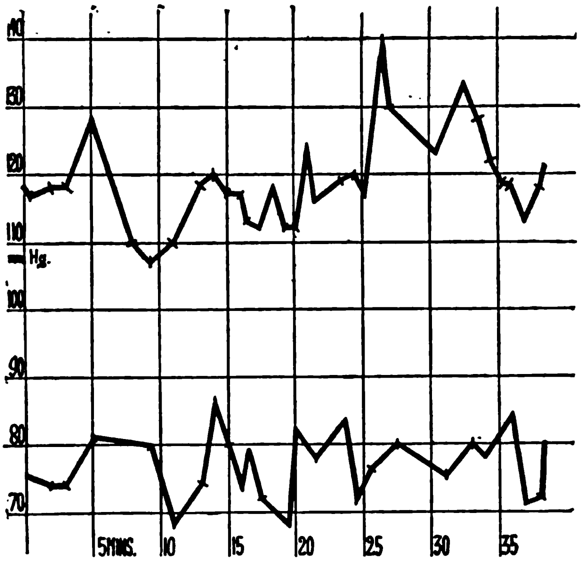

FIG. 1.—*Hemobarogram* B² 14. (Each square on the horizontal (abscissa) line represents five minutes of time; and each square on the vertical (ordinate) line means ten millimeters-of-mercury of pressure in the brachial artery as it is commonly measured at present with the cuff-sphygmomanometer,—in reality "too high." The upper graph is the systolic series of pressures, the lower the diastolic; the space between them represents the pulse-pressure at any moment. This blood-pressure record then is 38.5 mins. long, with 33 systolic measurements and 26 diastolic, the extremes being 140 mm. Hg and 68 mm. The diastolic was measured in this case by the old-fashioned "third-phase" criterion, now abandoned for the more certain criterion of "sounds gone." These graphs of course are to be read from left to right.)

Three rapid rises of arterial tension are shown in this hemobarogram, each involving (as sometimes does not happen) both the systolic and the diastolic phases. The first begins in the fourth minute from recalling a bad fire-scare years before; the second begins in the nineteenth minute from a slight feeling of recalled embarrassment; and the third in minute twenty-five from "heat and anger" recalled. (In the thirty-first minute is shown the brachial rise incident to multiplying 98 by 76 "mentally.")

The subject was a young-woman teacher (26.5 yrs.) in the Harvard Summer School, 1916. 11 a.m. Heartrate at the beginning 74, twelve minutes later 76, nineteen minutes later 78, and at the close 85.

Here, then, is the rise of blood-pressure developed as the result of disagreeable stimuli, a feeling of unpleasantness. Note the marked rise—a maximum of about twenty-three millimeters of mercury, twenty-three points —in the course of two minutes from the "mere" recall of some unpleasantness. It doubtless happens exactly like this and more lastingly from the mental or bodily irritation of a badly fitting gown or suit of clothes. Data are not yet at hand which would show the nature and degree of the chronic influence of persisting unpleasant conditions, save when they are on the verge of being pathological, when the rise-results are conspicuous enough.

The thoracic relations of breathing to clothes are still more conspicuous, and conspicuous in proportion to the normal, "athletic," development of the individual. But really it does not need elaboration that respiration is to a considerable extent under the influence of over-tight or locally constricting clothing. This matter became common knowledge centuries ago, and was thoroughly threshed out, medically as well as socially, by society women, novelists, and physicians.

C, Heart- and arterial action. These influences have never been adequately considered in discussing bodily movements and bodily comforts. It is not at all obvious but what the heart has (vagal) comforts and discomforts all its own, relating to direct compression of the thorax, and pressure indirectly upward from the epigastrium.

Young women used to "faint" and still do now and then, and the mechanical cardiac elements of the complex are not known; they may be of consequence. Their abdomens, at least, often were so tightly compressed that their viscera were pressed upward and there interfered with the free action of the heart. The first thing one does ordinarily when a woman "faints away" is to loosen her clothing around the abdomen and chest, and so give her heart a chance to beat normally again.

What we are especially concerned with at the present time, however, wholly new so far as I know, is the arterial tension, the blood-pressure, not only of the *skin* immediately compressed by clothes, but on the two principles of *"liquid" transmission* and of *reciprocity,* the arterial tension of the entire body, muscular, cerebral, and visceral.

My research-interests for some two or three years, have been quite a bit on blood-pressure, and I present some blood-pressure records (hemobarograms), made by my new quasi-"continuous" method, which illustrate very interestingly some of the conditions connected with clothes in regard to arterial tension. These graphs have not been prepared for this present purpose at all, but I think you will find them ápropos of our present work and very suggestive as well as interesting.

The *capillary* and *venous* relations between clothes and over-

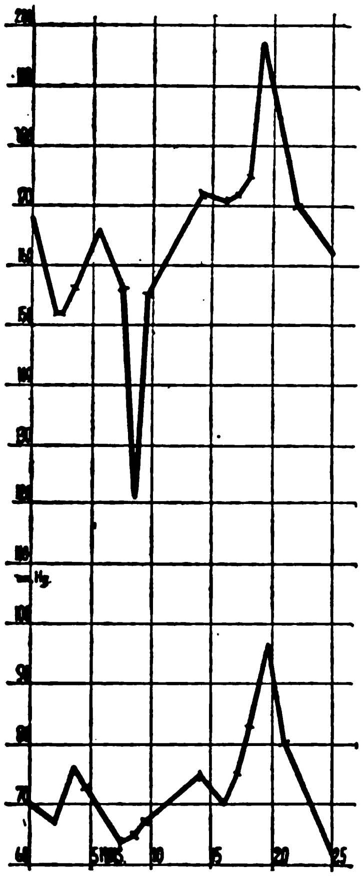

FIG. 2.—*Hemobarogram* (*part*) *A* 19. This graph represents twenty-five minutes out of a hemobarogram just two hours long made from a medical man who is an athlete and self-trained in various kinds of physiologic "stunts." The extreme arterio-tensional ranges measured during the two hours of that September, 1916, afternoon were: systolic, 74 mm. Hg, maximum, 196; diastolic, 35 mm., minimum 61 mm., sounds-gone method. (The plotted hemobarogram entire is 620 by 365 mm. in size.) The subject all the while sat quietly in his chair, be it remembered.

The systolic fall beginning in the eighth minute was occasioned by several full breaths plus relaxation; the subject's own words were, "I let go and was almost numb." The tension promptly sprung back. The rise beginning in the tenth minute was occasioned by excited talk about an expiratory method. The rise beginning in the seventeenth minute, in both diastolic and systolic observe, was occasioned by expiratory apnea—holding the breath with diaphragm relaxed. The tension snapped back to the average and the diastolic, as usual, below it. Number of measurements, 29.

This man was a Yankee nearly 50 years old; he had had, it chanced, nothing whatever to eat since 24 hrs. before. His heart-rate before the measure-

ments was 42, the same 75 mins. later, 21 mins. later 40, and at the experiment's close, 45; his "Sweedish-system" training is here illustrated.
This fall is due solely to relaxation and to deep breathing, two of the physiological processes which cannot occur in an over-tight and ill-fitting suit of clothes! Incidentally, these suggest the importance of systematic exercise, including the old-fashioned, "Swedish" habit of deep breathing. The marked rise beginning in the seventeenth minute (expiratory apnea) has little obvious relationship to the clothing or to its wearing, save that tight clothes would make such a rise easier.

tightness are already familiar to most of you, being more obvious than the arterial tensional variations. Venous stasis and congestions from compression by clothing are not infrequent where the sartorial conditions are bad enough whether from design or necessity. An obliging society-woman of "the old days," whose memory had remained undimmed, could relate more examples of these particular relations of clothes to the circulation than anyone would care to print. The intelligent gynecologist could relate more which would be still further impressive.

Besides the five hemobarograms reproduced herewith, there are many among the hundred and more in my present portfolio that are almost equally á propos to our immediate purpose of discussing clothing-fit. One systolic rise represents a state of unpleasantness; there is nothing particularly striking about it, but extreme unpleasantness often is due to improper clothes. Another is marked "worried," the individual meanwhile recalled a subject of worry. (I never inquire what stimuli exactly are, for I am satisfied to know that it is either pleasant or unpleasant.) Another shows a marked reaction at the recall into the mind of some old worry in a young woman. Here is a very marked reaction of pleasantness, some mode of pleasure that is imagined; there is a marked fall which is always the case provided the pleasantness does not excite, does not come as a shock. General pleasantness proper will lower the blood-pressure,—compare clothes satisfaction!

I am surprised to see that I can get as strong a reaction by asking a subject to think of an unpleasant thing or of pleasant action as from the actual thing. It is very striking indeed how somatically strong the imagination is; and this is a point that is worth while for our immediate purpose: Whether a person does "look like a guy" or not, if he *thinks* he does it amounts to the same thing, so far as the bodily reaction is concerned.

There is an extraordinary curve of the rise of blood pressure from holding the breath, a rise up to two hundred and thirty millimeters in a man who had been trained in breath-holding. This gentleman, Dr. J. G. Smith, held his breath two minutes and the thoracic venous congestion put his pressure up from his average one hundred and thirty-five to two hundred and thirty,—

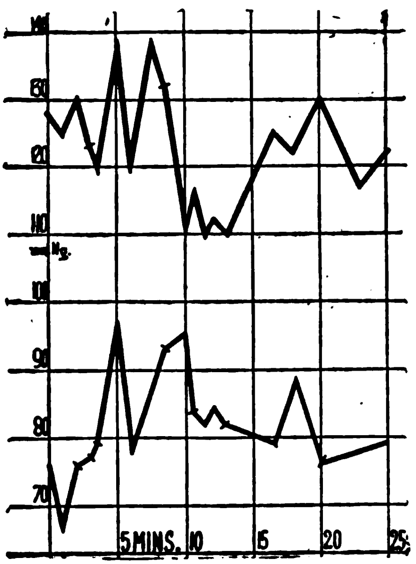

FIG. 3.—*Hemobarogram* B^1 4 shows, among other reactions, the vasomotion of relaxation of mind and body while sitting. In the systolic range the lowering began in the eighth minute, but the diastolic rose for a minute and a half. The rise in the fourth minute came from an exciting pleasureable memory; that ten minutes later from anxiety; while that in the seventh minute represents the powerfully dynamic concomitance, if not effect, of imaginary physical exertion: "chinning," pull-ups, in this case.

The subject was a most energetic fine tall woman of nearly 22; suspected to be "in love." Her initial heart-rate was 96; nineteen minutes later 76; at the end 84. The high rate at first may have been due partly to much physical exertion preceding the making of this set of 36 measurements.

The habilatory psychology of this hemobarogram is chiefly in the relaxation reaction inexpedient in clothing either tight, or irritating from malfitness.

in two minutes. That too has a slight application for our work, that the respiration should be free and that you should be freely able to take deep breaths, often.

There is a record showing the vasomotion of anger, a marked rise, though purely imaginary anger. I do not have to get my subjects really angry; merely to have them imagine that they are angry, or recall certain company, etc., is enough to have a great rise in the systolic and the diastolic pressures. That is the condition in which a tailor's patron is when he allows him to be angry when buying a suit of clothing. Plainly clothes have much to do with the emotions. Here is one which the subject reported his condition as "heat in anger"; he "got a little hot (vasomotion) about the collar," he said! But enough for now of the blood-pressure records. I have a hundred or so of these, and each one represents two, three, or four hours' work; but most of them are worth the while as human documents.

These conditions then, (to *summarize* the blood-pressure matter): Anxiety, worry, unpleasantness of various kinds, chagrin, grief, anger, terror, holding the breath, all tend to raise unduly the blood-pressure. And, on the other hand, pleasantness and calm pleasure, satisfaction, relaxation, and deep breathing tend to lower it. In general, local and general compression would tend to stand for the first group; and lose and perfect "fit" ness would tend to make, of course, for pleasantness and satisfaction. (See below.) It may be always kept in mind, as of basal practical and psychologic importance, that it is the emotional tones, the pleasantness and the unpleasantness, and the excitement, of emotions which provide the motives of behaviour, both vegetative and deliberate. *Clothes* have very strong emotional interests for most women and children and men, and their influence would be undeflected by ideas.

The accompanying hemobarograms, then, show on one hand the effects of "inside" influences: chagrin, anger, terror, and holding the breath, toward *raising* the peripheral arterial tension. Others of them show the effects of mediate pleasure, of pleasantness, motor and mental relaxation, and of deep breathing, in *lowering* the arterial tension. The first group, tending to raise the blood pressure, is brought about in general by constriction such as would be caused by generally too-tight clothing. On the other hand, clothes-*fit*ness such as we have already considered, and general loose accommodation to the body, equal in all places, would make for low pressure, in the way of greater comfort and life-satisfaction. These sample graphs and the legends which accompany them make apparent this rather important relationship of clothes to the essential blood-supply.

In his earlier experiments on surgical shock, Professor George W. Crile of Cleveland had made for him a complete suit of hollow rubber clothes inflatable with air from a pump, the intent being to compress the body of the shock-victim and to exert a uniform and considerable pressure on nearly all parts of the skin. The object of this elaborate and bothersome experiment was in brief to raise the peripheral blood-pressure of persons who were dying because their arterial tension was far too low in the central

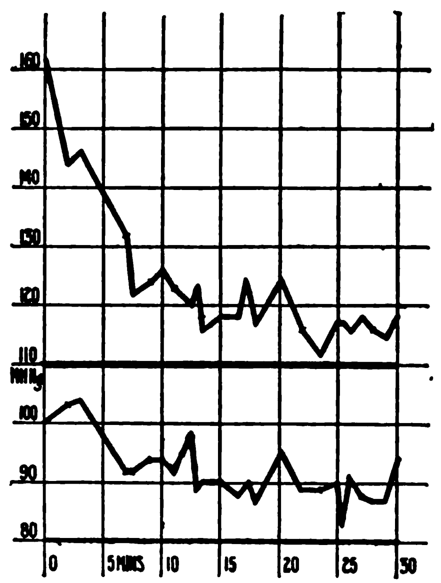

FIG. 4.—*Hemobarogram* $B^{2}22$. This is the thirty-minute record of a woman of 42 years who tests only 1.6 years on the Yerkes point-scale system of tests. When the cuff was first distended (170 mm. Hg.) she burst quietly into tears, emotionally shocked at the novelty of the painless sensation. Within the next 13 minutes her systolic brachial-artery tension had fallen 46 mm. Hg., her diastolic 11 mm., her heartrate falling meanwhile from 112 to 88, where it remained. Within seven minutes from the beginning she was in her usual good humor. This record, atypical of the hemobarograms of mental defectives, is presented solely to illustrate the physiological "limit" of blood-pressure rise (due purely to office-apprehension) and its spontan-

eous fall under the more usual office conditions. Very many persons, both adults and youths, some of whom would "test up" rather better than 1.6 years Yerkes, show just this kind of blood-pressure phenomenon—however little the "rank and file" of physicians as yet realize it.

Heart-rate before the measurements, 112, fourteen and twenty minutes later and at the end each 88. Measurements, 51.

Here is a record that importantly shows the fall of blood pressure from becoming calmed down with the loss of anxiety. I have a scientific grievance against the medical profession, in general, although I am a member of it, that they have been "taking" blood-pressures once or twice when up and only then, wholly regardless of the fact that perhaps ten minutes later it has fallen thirty or forty millimeters.

For our *present* purpose, this clearly represents the marked fall of arterial tension when one ceases to be worried about anything. This, I take it, will appeal to a young woman perhaps more than to a young man:—if she have a suit of clothes on that has in it or on it absolutely nothing about which she can worry, you might expect to lower blood pressure in that manner; and to keep it low! "The peace which religion cannot give," as the lady explained to Herbert Spencer. Habilatory science must apply itself in part along this direction, thus lowering the prevalence of Americanitis.

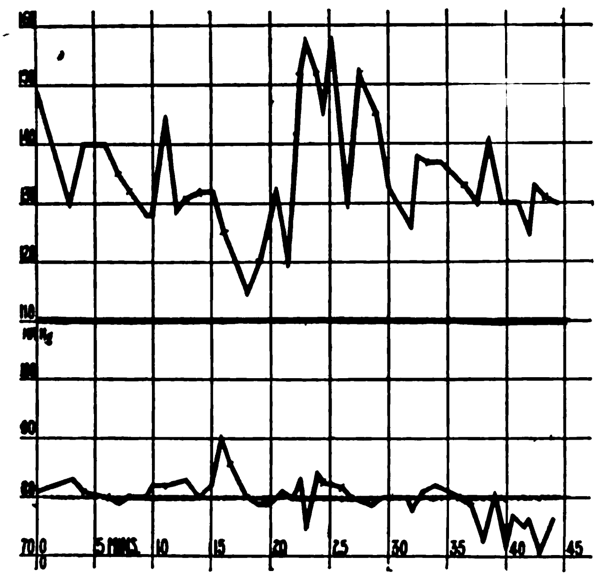

FIG. 5.—*Hemobarogram* A17. This patient was a woman nearly sixty years old, normal, but typical of the Yankee women who are always busy and usually worrying about something, imaginary or real, be it only their clothes, at rare intervals. The variations here are spontaneous nearly, and with a systolic maximum of 42 mm. Hg in 5 minutes and a diastolic maximum of 15 mm. Hg in 7 minutes. The diastolic curve shows the relatively small variation characteristic of the arteries after fifty years. The heart-rate remained about 60.

The systolic rise from 128 mm. to 144 beginning in the tenth minute was "from" a momentary anxiety; the relief-reaction (to 115) is rather striking. In the twenty-second minute there began a very marked systolic rise (from

120 to 157 mm.) due to the sudden onset of "worry" (as the protocol reports it), and generally sustained for nearly three minutes. This vasomotor constrictor spasm is weakly reflected in the diastolic series of measurements.

When rises such as these occur from slight anxiety in a woman of sixty or so with normally sclerosed arteries, it is easy to believe that in many younger women clothes-worries and chagrins considerably upset the equilibrium of the vasomotor system.

nervous system, the vegetative vital processes, therefore, being in a state of rapidly mortal decline.

Over-tight, universally over-tight, clothing must act in the same way as Crile's shock-suit, namely to raise the blood-pressure, but now when it is already high enough, and so to help continue and make worse the rather notorious "Americanitis," (inflammation of the American) the pace of mental tension and general strenuosity that kills. General irritation or compression of the surface would at any rate materially tend to congest the viscera and the brain, irrespective of the actual arterial tension in any part of the body. The skin, as is well known, is one of the five great vasomotor reservoirs for the blood; and if by compression its arteries and arterioles are flattened, a large amount of the blood must be forced into the viscera and the brain. Until we are certain of the truth of the finding of Professor Jno. F. Shepard that sleep involves cerebral congestion, the precise significance of this reciprocity must be still more in doubt even than heretofore. My own vasomotor observations tend to corroborate Shepard's results, and from an entirely different source. This whole matter is well worth emphasis in the psycho-physiology of clothing, for what it may later (when we know more about vasomotion) prove to be worth, which probably is much.

Clothes to a degree fit themselves. This auto-fitting of clothing to the action of the body which it covers is more or less proportional, and in various ways, to three characteristics: 1st, to their material; 2nd, to the amount of use which the clothes have; 3rd, to their tightness. This automatic fitting tends to come about, it is plain, by the process of stretching where the garments are relatively fight, and of wrinkling (often fairly tightly) where the costume is looser. A week's wear is necessary to make a suit really fit the man's body in its quiescent shape and also in its action. This is a practical point which tailors seemingly should take into consideration if they wish to do ideal work in every way for their patrons, and to leave them wholly content in and therefore with their clothes.

D, Voluntary movements and posture. Skills. We come here to the consideration of voluntary movements, not more important for life, perhaps, but far more interesting and more psychological than the three groups of influences and relations we have just considered. Skill of a thousand kinds and grace of many varieties, the two combining into various kinds of efficiency, are concerned with clothing in this particular respect. It is the movements, the behaviour, of the man which is the important thing, and not, so to say, his chance shape when he is standing on the tailor's stool to be measured. Old clothes fit, and therein mostly arises the common satisfaction of wearing them, especially when one is at work. The psychology of this runs perhaps somewhat thus: The control of voluntary movements, of all movements in fact, is largely by the inherent sensations of the action-system, formerly and technically called the muscle-joint sense, but now increasingly often and more properly kinesthesia. These guiding inherent sensations are normally (save in new and truly voluntary movements, which are *rare*) more or less subconscious or even wholly unconscious. It need not, however, be suggested at even this early stage of physio-psychology, that such sensations are none the less effective because they are subconscious.

These sensations and subsensations constitute, it is plain, the chief of the sensory influences, in fact of all the afferent nerve-impulses, that are of practical, work-a-day value in a world still and for many centuries to come primarily a work-a-day world. Their nature in somewhat greater detail, based on research, the present writes already has set out.* Perhaps one may repeat two or three paragraphs relating to the neurologic conditions of skill, from that article:

Between these partially opposed types of motor consciousness

*G. V. N. Dearborn: "Kinesthesia and the Intelligent Will," *Am. Jour. Psychol.*, XXIV, 2, April, 1913, 204-255, illstd.

are many indefinite degrees, apparently, according as a given limb is more or less skilful in a given group of movements, in number of course uncountable. It is, then, one of the inductions of this experimental work that *the motor skill of a person in general, and also in particular actions, is more or less proportional to his habit and capability of using the conscious kinesthesia* for the current inhibition of actions elsewhere coördinated and actuated. As has been shown already this actuation comes from (spinal?) kinesthesia in combination with external control, usually either visual or auditory. We are rapidly learning that all bodily processes and conditions are the algebraic resultants of balanced tendencies, whether nervous, chemical, or mechanical. The neuro-physiology of skill as in part determined by the afferent neurograms of movement, certainly is no exception to this rule. The unconscious and the conscious, the actuating and the inhibitory kinesthesia, surely share and complement each other in motor control. A person's skill, therefore, appears to be a 'function' of his habit of usefully *fusing together* his motor ideas proper and the resident movement-sensations which in him are adequately conscious. Compare Slinger and Horsley's conclusion that "the muscular sense under necessity can, by education, be brought to a point at least one-fourth better than that learnt by a normal seeing individual."

But, again, compare the practically unanimous opinion and practice of instructors in all kinds of motor efficiency (music, instrumental and vocal, manual training, physical education, legerdemain, etc.) that attention to the sensations of movement disturbs the performance and is therefore to be avoided. At least one successful instructor in voice, of my acquaintance (Mr. B. G. Willard, late of Harvard University and now of the Sargent Normal School), makes this avoidance of local consciousness the very key-note of his method, substituting therefor an intensified general consciousness of effort.

Reconciliation of these two attitudes, one academically scientific and the other purely empirical, but both obviously true, would seem to lie in what has been learned in these experiments, if indeed skill does consist *in a trained fusion of the extrinsic motor ideas and the intrinsic inhibitory conscious control.*

As the original research-report in the Journal für Psychologie und Neurologie (January, 1913) showed, these conscious motor skill-sensations probably are inherently inhibitory, as is the neopallium of the cortex cerebri, their "center." If therefore they are shut out of the conscious mind or disturbed to a practical extent, impulsive action is in no wise prevented from its function to "carry on," but the fine coördination of forms of motor skill, including grace, is destroyed and the productive practical efficiency coming from skillful ability, for the moment or for good, is lost. As already has been suggested, the vexations and discomposing sensations of the skin, of the kinesthetic regions, and of the viscera produced by constricting and otherwise ill-fitting clothes, are just those sensations and irritations, fully felt or not, which would be *most apt to disturb* the skillful flow of the skill-neurility.

These same considerations apply to *grace,* which concept relates always properly to movement actual or implied, kinetic or potential. Veny recently (1917), G. H. Browne (of the Browne and Nichols School, Cambridge), himself a skilled fancy skater, has published at my suggestion, in "Mind and Body," an interesting discussion of the psychology of grace, and also, a few months later, a translation of the first chapter of the third part of Souriau's neglected "L'esthetique du mouvement" (1889), found in Harvard's Philosophic Library, and referred to and quoted from by Vernon Lee in her refreshing books. Both of Browne's articles provide timely examples of graceful movement, to which the clothing concerned, both subjectively and objectively (see below), has direct and important relation. Inasmuch, however, as grace is only a glorified aspect of skill (with beauty added to utility as its goals), we need make no special study of it here. The same principles that apply to skill apply also to grace, a form of skill.

Avoidance of this clothes-cause of awkwardness and of motor inefficiency, thus due to an unnecessary (and still unnatural!) source of distraction ("man by nature is a naked animal"), may be reduced to a requirement that *local clothes-consciousness, indeed general clothes-consciousness, should be avoided.* The whole world in its bodily work demands this relief, whether it be an endowed philosopher elaborating a fine metaphysical knot or snarl for some endowed "Kantian Journal," or the equally useful body-"laborer" helping to dig out a new city-subway; or milady murdering sleep and Stravinsky (who "jolly well" deserves his fate) on her rosewood concert-grand. The whole world gets something of this relief too, because every body-worker wears some adapted form or aspect of

Work-Clothes. This phase of our clothing is the best available sign that the rational human worker in the long run everywhere tends to adapt his raiment so that it will not limit in any degree his bodily action, thus lessening his basal vocational skill, earner of his daily bread. It is doubtless true that the worker realizes this not at all or at any rate less fully than he realizes the other reason for work-clothes, namely clothing- and money-economy. But try to imagine Kreisler playing his violin at a concert when he was wearing a coat with arm-holes too tight! He would from preference, I doubt not, startle his conventional but easily appeased audience by playing to them in his bath-robe.

Consider the increasing hundreds of trades and occupations over the world and see that each, in forest, work-shop, or in *atelier,* has its own work-clothes more or less characteristic, from the loose coarse breeches of the sweating puddler to the elaborate mask or armor of the dangerous trades. Most of these sets of clothes are directed toward the securing of the greatest expedient *freedom of bodily and of mental movement.* Otherwise they would not be workmen equipped for their work, but dilettanti in the popular sense of the word.

Each movement, more or less, is a unit of behaviour represented by a definite brain center, as is shown indeed by their specific derangement, technically called apraxia. These centers seem to be situated especially in the frontal (and parietal) lobes. Smooth action, then, of every sort, skill, grace, and efficiency in any motor ability, are more or less dependent on good bodily attention and neuromuscular tension (corpus striatum?), on the undisturbed process of control from the fore-brain. These impulses coming from the central nervous system, especially the brain, are what are called, of course, motor ideas. If they be interrupted and disturbed in their flow, especially by a purely artificial stimulus, vision is brought in to control the motions, displacing and deranging the normal governing kinesthetic impressions and giving them extrinsic control of the actions, but making the latter jerky, angular, and unskillful.

Now the restraints, discomforts, irregular pressures, irritations, constrictions, lack of support, and other bothers of ill-fitting clothes (in man, perhaps, more than in woman?) are *precisely the kind of interrupting sensations most certain to disturb ideal bodily action,* so intimately are they related to the disturbed flow of kinesthetic sensations. Such intrinsic sensations of the skin and of the action-system within it disturb personal psychomotor action far more than would more conspicuous extrinsic sensations such as sounds, voices, odors, and the seeing of moving objects, coming from without the organism. Work-clothes, then, as old clothes, mean to efficiency far more than economy of clothing-cost,—they mean an excellent *fit* by bodily adaptation, stretching here and wrinkling up there, so that comfort remains at its maximum and undisturbed. This happy and yet familiar condition of clothing-affairs prevents those distractions of the inherent movements and sensations which actually control the organism. To be perfectly at ease when clothed, this kind of ideal fit, acquired only by actually wearing the clothes, is indispensable. Otherwise there is either the discomfort leading to the combined inefficiency, or one form or another of a bad form of clothes-consciousness which, as we shall see below, is a mild emotional state which in itself and for the moment of course is distracting. This matter would bear qualitative and quantitative elaboration in a laboratory.

E, Considerations of general behaviour. In this discussion of behaviour, we refer now to one's social movements among his fellows and to one's habits in life so far as social communications are concerned. This phase of human behaviour is more determined by clothing than many have ever stopped to think or to realize. Without much thought, the following at least may be suggested as social movements greatly or slightly, as the case may be, determined by one's raiment, and others there are a-plenty.

1, How much one "goes out," both into the street, and

2, Into society in general, how many "calls" one makes;

3, The time of day or night at which one goes out when living in town, for several reasons.

4, Where one goes, that is, the sort of place to which one goes, both in town and in the country.

5, How much company one invites to his home, and,

6, To some extent, the nature of that company.

7, How much one attends church, disgusting Easter parades, etc.

8, How much one attends the theater, and the nature of the entertainment so designated, whether it be a dark movie among often unfashionably or ill-dressed people, or the grand opera with its brilliant promenade and conspicuous visiting.

9, Clothes frequently help people to get "jobs," and to hold them, but (see below),

10, Clothes help others to miss positions and to lose them.

11, The amount of exercise one takes and its variety are determined to a considerable extent by one's habits of dress, and especially perhaps by one's laziness in regard to the frequent changing of one's clothes.

12, How much one sits and where and how one sits. (One thinks here of the attention which the "dude" pays to the creases in his trousers, and even dignified madam to her dress-skirts.) (When I was a young lad it was inevitable that a boy having a pair of "hand-me-down" trousers thrust upon him should take them first to a tailor that the creases in them might be wholly removed!) And sitting has much to do with the adolescent maldevelopment of the pelvis, concerned in the birth-rate.

13, How much one eats and drinks (the very basis of much bodily comfort) is determined to some extent by the clothing.

14, How much checking-balance one may keep at the bank, determinant of behavior to a noteworthy degree.

15, One's personal beauty (in the case of the beautiful sex.)

It is obvious that even in a list thus laconically set down there are topics enough for several essays in the socio-psychology of dress. Some of these essays if they reached as far down in the fundamentals of human biological nature as it is meet they should, would prove of importance in the unravelling of quite a bit of human motivity.

The last has a perhaps appropriate word at this point. Bodily beauty is as much a matter of behaviour, of action, as of structure. Males human have no personal beauty in the proper sense of the term save this beauty-of-action, but the female (child and adult) enjoys (and often how keenly!) both kinds of beauty. As we have seen, improper or ill-fitting clothes readily check free and graceful action, and perhaps all but abolish whatever personal beauty a baby girl, a girl, a young woman, a woman, or an elderly woman may exhibit to herself as well as to others. Thus clothes, feminine clothes especially, tend to determine by limitation the life-beauty of their wearers.

Sixty years ago Herman Lotze published several pages in his well-known "Microcosmus" which come very pat into our present discussion, although unknown until quite recently to the present writer. He suggested three points, each of which has a good deal of psychologic interest:

1st, That clothes often tend to expand the personality, and in several ways, each of which is of basal import. Clothes, or at least parts of one's costume, may be considered as a kind of implement, he points out, to the outer limits of which our personality tends always to expand. In using a chisel, for example, a man's personality is on the bevel or on the edge of the tool. In like manner, in using or "wearing" a cane, one is apt to have his attention at the further end of the cane, or at the proximal end, or at both ends. High heels act in somewhat the same way. Swagger-sticks, so common now, and crutches obviously tend spatially to expand the personality; so do high hats, very broad hats, coiffures like those of Elizabeth's day; even bustles tend to extend the individuality of the wearer and in a direction at which one "wonders." But compare certain wellknown ideals of gluteal obesity still fashionable in the French Congo! In my "Emotion of Joy," 1899, I emphasized other factors and conditions of this personal expansion and motor extension, but wholly missed this sartorial one which Lotze suggests. In a smaller way thick ulsters, topcoats, furs, clumsy overcoats, and superfluous wraps are a badge of enlarged personality of their wearer. It is plain from the frequency with which well-to-do light-headed people assume these implements which connect their personalities with the environment that there is always a great amount of pleasantness and often snobbish satisfaction connected with their use. They are in fact an important factor in social life among naive people who pay over-attention to such extrinsic matters.

The second point which Lotze makes is that clothing often lends a joyous sense of motion, and especially of the freer motion, to its wearer. Flowing garments, hanging or waving drapery, nodding millinery, and so on *ad extravagandum,* make us "feel as if we ourselves were present in the gyrations of the freely flowing ends," as Lotze movingly expresses it. To the philosophy of the pragmatic ME we actually are so present, of course, for the personality so seen includes all that immediately concerns the individual. But more than one's actual clothes, all hanging, nodding, swaying ornaments (bags, plumes, belt-ends, ribbons, coattails, lapels, furbelows, veils, tippets, scarfs, hatbrims, wide-flowing skirts) act in like manner to lend a sense of vivacity to the wearer, and even to the observer by the principle of empathy.

Kinesthesia comes in here too, and explains how this interesting effect of action is produced by subconscious stimulation of the movement and freedom which stands in general for youth, for freedom and so for happiness. It is like seeing or feeling one dance, which gives all rightly-minded people considerable pleasure (See below). And the social relationships of clothes go even further than this into sexual attractiveness as Robert Herrick, wise man, keen for such feminine things, points out in his familiar poem:

> "A sweet disorder in the dress
> Kindles in clothes a wantonness:
> A lawn about the shoulders thrown
> Into a fine distraction;

An erring lace, which here and there
Enthrals the crimson stomacher;
A cuff neglectful, and thereby
Ribbons to flow confusedly;
A winning wave, deserving note,
In the tempestuous petticoat.
A careless shoe-string, in whose tie
I see a wild civility;
Do more bewitch me, than when art
Is too precise in every part."

Silks, therefore, thin, light, but not too precise, easily flowing by the bodily motion as well as by the breeze, make, for purposes of grace, the ideal fabric, especially light Chinese, Indian, and Japanese silks, and chiffons.

On the other hand, heavy ceremonial silks, for example the black grosgrain skirts which some of us remember in our childhood "that would stand alone," give the restraint which we shall next consider, following Lotze, as well as the expansion of the personality and the organism which we have just discussed.

Soft, light-weight silks, therefore, are the most psychological material, so to say, for at least feminine dress, not only for their own beauty and warmth, but for their extension of the activity, real as well as imaginary; and not only those of the wearer, but of the observer as well.

The third point which Lotze makes, relates to the tightness of clothing, especially to stays and corsets, and we might add, to the tight coats of the British "Tommy" on parade, of five years ago. Says Lotze, "The greater or less tension and firmness possessed by the material in itself or due to its cut, is transferred to us as if it resulted from our bearing." That is, a corset's firmness on all sides, thinks Lotze, makes us feel as if we ourselves were thus firm and self-reliant. Constraining garments thus may at times tend to give some one a self-consciousness which has distinctly self-exalting features, as here suggested, but personally I think that far oftener this oppressive restraint works quite the other way, namely to lessen self-confidence and to limit one's tendency to initiative and to action. It acts as a ***suggested discouragement,*** and therefore is "all to the bad" in the majority of cases. The important matter of arterial tension in this restraint connection has been discussed already. One paragraph from Lotze's four pages is so good in various respects that I need not refrain from quoting it:

"With this sense of firmness which she does not quite despise, the maiden mingles the feeling for easily moved and finer garments, for as a matter of fact the fragrant folds of the light and gauzy stuffs with which she drapes her form are not merely intended to be graceful in the eyes of others. On the contrary, the wearer herself is by feeling directly present in all the graceful curves that with featherweight touch but a few points of the skin, and yet through these points excite the most distinct sensation of the breadth, lightness and softness of their sweep. Nay, often the pleasure afforded by such a sight is derived far less from the pleasing effects of the drapery we see than from the fact that we can transport ourselves by thought into the imaginative joyous or dainty vital feeling which the myriad petty impressions from the garments must infuse into the form which they conceal." One could scarcely find a better suggestion of empathy than this from Lotze; see the remarks below.

To interpret these undoubted facts, we must seek practically the same conditions that underlie the subjective and the objective pleasantness of dancing, skating, swimming, and "calisthenics." This, in short, is the psychology of skill and of grace into which Mr. George H. Browne, for example, has recently ventured.

Kinesthesia in its relations, first, to bodily, and second, to mental control; third, to the imagination of the consciousness of others; and fourth, to bodily attitudes as determinants or concomitants of emotional states of mind, (as the James-Lange theory of emotion shows) is concerned here, of course, importantly, in an explanatory way. The muscle-joint sense, so-called, as the connector or index between bodily motions and strains and our mental processes, is here of satisfying explanatory importance. This matter, however, is of such a nature, so complex and so subtle in description that its exposition would require more space than can be here afforded, and must be postponed, to be done, it may be, elsewhere.

This feeling, however, of a perceived person in graceful action, and the mediate realizing of the sensations and the excitements and the low emotional tones which the dancer or skater is with delight experiencing, is what Lipps many years ago termed Einfühlung and what, as you know, Titchener has recently named empathy, and expounded in various directions. Empathy certainly is of permanent importance in the psychology of clothing. For example, each individual who personally "dresses," wishes every observer of her success to get into empathy with her; to realize how much her clothing is adding to her personality; to appreciate how much satisfaction and enjoyment it is giving her; and to estimate, even at the value which she sets upon it, how much it adds to her personality and to her importance, personal, matrimonial, and social. Plainly empathy has kinesthesia as its heart and stomach, as well as its skeleton. Such imagined kinesthesia, second-hand, as it were, is one more evidence of the frequently quite indispensable subconscious aspects of mind in our behaviour, both personal and social, and every instant of our lives.

The psychology of the discomfort and unpleasantness as well as the inefficiency which come from the expedient if not forced ***inhibition*** of naturally free bodily movement, or even from their compelled restraint, by some passing fashions in clothes, is not so briefly statable, although even more important. It involves obviously that basal physiology which relates to motor inhibition. Some of the underlying conditions are suggested in my "Notes on Affective Physiology" (*Medical Record,* New York, 89, 15, 8 April, 1916, pp. 631-641, illstd.). This material explains scientifically the reason why tight, stiff, and cumbersome clothing lessens efficiency both directly (by mechanical restraint) and indirectly (through discomfort and inhibition) that is, physiologically and psychologically, Lotze, a man of the most excellent wisdom and breadth of view, to the contrary notwithstanding. This material following provides the foundation on which a scientific art of adequate dressing might perhaps be erected, for it explains the psychologic basis of limitation and of restraint, both of which modern clothing implies.

Too little emphasis certainly has been laid upon the twofold nature of human personality, upon the complete *duality* of man's nature, especially to its physiologic and psychologic foundations. Poets and philosophers have seen and beautified its moral aspects, and have shown in terms that cannot be forgotten that the sanction of our very conception and incarnation and birth and living lies all but wholly in the logical necessity of developing individual personalities through temptation, struggle, "denial of the will-to-life." Whether we see it every day in the unselfish self-denial of the dear women in our own households or read in leisure hours of its esoteric system in the wilds of ancient Thibet, we are continually aware that it is one of the dominants of our actual world.

And when we turn to the anthropologic aspects of this same matter we find our fundamental just the same and find it closer to physiology and neurology. The phylenic "series" shows at first a preponderance of biologic egotism, of racial impulse, of pleasant activity, expansion, push. There is excess of movement over control, the utter mechanism of the plant, the tactic processes of the protozoa, the simple behavior of the early metazoa, play, the noise and irresponsibility of childhood, the dance, boisterousness, freedom of every kind, the grand flourish, license, extension of personal and family and national power, "might makes right," "to the victor belong the spoils," force, great guns, invasion, pleasant hopes of conquest, freedom to progress even in the sun regardless of all but one's self.

But the secret of the sanction of our incarnation lies not here! Rather does it lie in a process which uses all this as Emerson says, "as hands and feet" by which it may accomplish its great world-purpose each in his own individual way. I mention such relations in this discussion of physiology (which ordinarily tells none too much of God and personality), only to show how important and basal and deep and universal are the ramifications of world-processes which at heart are in practice muscular and nervous and even epithelial. And it is worth while to see it so.

Man, then, generically and individually becomes civilized, even if slowly, grows up, attains the full measure of a being who "dares do all that doth become a man," even to attempted conquest over the vegetative and biologic machinery which gives him his *energy*. He restrains his impulsive machinery, serves as governor to his flywheel, so to say, often so massive and with such dreadful inertia of motion! He learns to inhibit especially his emotions and thereby, more than in any other way, qualifies for a citizen of our little world against whom that world will not rise in wrath. It is of course now our hunt to trace out some few details at least, or relative details, of the nerve-paths and nerve-knots of that inhibition, especially in relation to the algodonic tone of the emotions and the feelings.

It has already become reasonably certain that *freedom in itself is pleasant,* and that *restraint* biologically speaking—that is, naturally, in naïve individuals—*is inherently disagreeable,* whether from without or from within. I would emphasize the provisional clause in this part of my thesis, "biologically speaking—that is, naturally, in the naïve individual," for we shall suggest below that it loses this unpleasantness as the person becomes a psychologic personality. As the wise "George Eliot" says in "Felix Holt," "There is a sort of subjection which is the peculiar heritage of largeness and of love; and strength is often only another name for willing bondage to irremediable woes." We all know that freedom as such is pleasant, and a seven-foot shelf of books, or one even longer, might be readily written, given time, to extol freedom's pleasures in every possible realm of human experience. It has, I think, not been often effectively suggested, on the other hand, that in the unsophisticated animal, dog, or child, or savage, inhibition is essentially and inherently unpleasant (until, by submersion—see below—its disagreeableness has been mostly lost). * * * *

It seems to suffice for our present concern in clothes-physiology to point out that the inhibition of impulsive tendencies (mostly pleasant on well-accepted principles) is by their very nature usually an unpleasant process. Even if unaware of the fact from personal experience, the reader cannot fail to realize that sometimes the restraint of our impulses, of our biologic, vegetative instincts in particular of course, rises into the heroic, involving as it does a maximum of struggle against unpleasant lacks of action along ancient hereditary paths. To restrain one's fatigue, one's wrath, one's hunger, or one's lust is oftentimes, to many men and women, their experienced maximum of disagreeableness. These are gross examples which the check to the onrush of biologic satisfactions, teleologic intentions, sufficiently "explains" to the average student of neurological psychology. It should, however, be noted as we pass them that in this contest between an impulsive process and a tendency to its restraint obtains the precise relationship to which early psychological biologists (*e.g.* Romanes) ascribed the origin of consciousness in the evolving phylenic order. McCabe's notion is far less satisfying: he actually refuses to admit the consciousness of animals less complex than birds, a truly Cartesian sophistry; but "the worse is not the better reason," after all.

For our present purpose it is an important consideration that in the personal, as well as in the social consciousness and memory, unpleasant experiences actually are more conscious, more vividly real, and much more memorable than pleasant experiences. And this is true as a well-realized fact wholly independent of any theory of feeling or of neurology. It is the blizzards, not the periods of delightful weather, which are remembered; a moment or an hour of agony agitates the memory long after ecstacies have gone, almost past recall. This is not due to some inherent pessimism in the human mind, we may be sure, for the majority of folk are practical optimists. It in part is due, say I, to the basal physiologic condition of innervation, namely that ***the conscious restraint-kinesthesia underlying mentally the movements concerned is more closely related to unpleasantness than is the actuating movement-neurility.***

Another reason doubtless arises in the fact that the grand mean balance of human experience is pleasant rather than unpleasant; on this basis alone would a human people with power of initiative to suicide remain in the long run alive, for "Lo, you are free to end it when you will!", as William James again reminded us. Here, then, is a background of moderate pleasantness and against this the lurid experience of pain or of the disagreeable in any mode stands out with far more distinctness than would an experience toned like the background. As we pass, it is worth noting that almost all the behavior of the average adult is physiologically impulsive and reflex and semi-automatic, what we may best denote perhaps as habitual voluntary action. As thus impulsive it is pleasant because relatively free. As this voluntary and inhibitory only to a slight extent, strictly voluntary only at extremely rare intervals and in many persons never, after childhood, it has little of the difficult unpleasantness which is related to the kinesthetic foundations of restraint. To the galley slave, "Jean Valjean," life for just the opposite reason was unpleasant and revengeful, inhibitory, fearfully voluntary, a memory to embitter eternity. We return then to our scenario with widespread evidence that free action is by nature pleasant and inhibition, characteristic of voluntary movement, whether devised from within or forced from without, difficult, unpleasant, and hard. * * * *

We are especially concerned now, therefore, with inhibitions that are voluntary until by habituation they have become more or less mechanical. As example of one of these basal voluntary inhibitions closely related to the emotional tone-balance consider the checking of muscular movements when listening to real music. By real music is meant music with a wellmarked rhythmic beat. If one attend many orchestral concerts, even where the music performed is of the very "highest class" and the audience the most "cultured" group of society, it cannot fail to be noted that the spontaneous, that is real, enjoyment is greatest from the music with strongly marked rhythm, and least, with a forced fashionable applause if any, at the artificial concoctions which ramble instead of march. At a recent concert, for example Beethoven's symphony in F major (Eighth) was in contrast, after an intermission, with Stravinsky's impressionistic and unrhythmic "Feuerwerk," vastly to the hurt of the latter, bad as it is. Some of the modern music forgets or ignores this neuromuscular basis of musical emotion and offers concatenations of harmony when the truly appreciative listener craves only what his inevitable organism demands to satisfy it—sympathetic and synchronous activity. Thus music or that which pretends to be music now and then strives to express ideas when its sole language properly is feeling or feeling with a tinge of will.

True music then, we are sure, has a well defined rhythmic beat and is met in the naïve and natural individual at whatever age by voluntary muscular movements of the feet, head, or hands; within oftentimes are corresponding but ill-defined contractions of the vegetative organism. Now to inhibit these (unfashionable because disturbing) movements is distinctly an unpleasant effort and takes away from the musical enjoyment and continues to do so in a measurable degree at least long after the inhibition-habit has been thoroughly acquired. One longs subconsciously, so to say, that he might hear such music when he were free to meet it in the natural way. Here, of course, is the basal psychology of the dance, and likewise to watch dancing while standing or sitting still is an unpleasant experience and that despite the joy from the well-marked music. In all this, it seems plain, we have the somatic (neuromuscular) prototype of the pleasant unimpeded impulse and of the unpleasant experience of inhibiting this impulse, both being essentially kinesthetic.

This vegetative impulse furnishes the ways and means, the thrust and push, the substantial and inherently enjoyable activity even to abandonment which makes life interesting. On the other hand, the restraint of all this to suit the needs of a social environment, requires strife and weariness whose only reward is itself. There is here, however, the half of the personality, in fact that part of the total human behavior which is commonly deemed (but wrongly, we may see) the very essence of humanity, of civilization, culture, delicacy, or whatever other term marks off for us our proud humanness from brutishness. * * * *

On the contrary there are two things (they appear to be but examples of many) which suggest that, to the young child, restraint, inhibition, personal control, whether in voluntary movement or in the feelings, is eminently unpleasant: First, the extreme infrequency of such acts of will, in itself prima facie evidence that they are disagreeable experiences, since agreeable acts tend to be learned early and to be frequently repeated. Second, direct observation (see, for example, my "Moto-Sensory Development," p. 89, Day 211) shows a long latent period (ten seconds or so) for such difficult voluntary movements, resolved at length by a quick and frequently clonic motion, the whole suggesting difficulty physiologic and hesitation and unpleasantness psychologic. * * * *

Moderate feelings, weak emotions, are certainly not all pleasant (worry is a notable example), nor are all strong feelings disagreeable. But, on the other hand, there certainly is a correlation between the novel inhibitory or hesitational difficulty of an innervation and its unpleasantness. The ancient wisdom that one in time becomes accustomed to anything is but common recognition that emotions tend to lose their original unpleasantness by use, by habituation on the universal principle, whereas novel environmental situations producing strong emotional reaction have with them usually an admixture of unpleasantness. This, physiologically, I take it, is a restraint, a hesitation toward the unfamiliar, an example of the inherent unpleasantness of uncertainty.

Integration.—Possibly the above considerations are already enough to suggest to an unprejudiced mind that there is some kind of a direct relationship between doubt, hesitation, restraint, and inhibition proper and the unpleasantness of feelings. This concomitance seems based in the dual structure of the nervous system itself, and it is perfectly possible but not yet to be actually proved in a corresponding duality in the mechanism of muscle, both voluntary and vegetative.

The fears and unpleasantness and restrictions of ill-fitting and ill-adapted raiment; and the freedom and empirical satisfaction of clothes that are adequate, really adequate in the sense defined in this monograph, cannot but be based in this fundamental opposition-in-complementation above indicated.

Underlying many of the human motives is one of the deepest of human satisfactions, (and at heart a worthy one) the esteem of our fellows. An aid to our egotism or even vanity in many cases, usually, none the less, it is an important element in expedient "success" and in the development of our personalities, save in the most "exaltedly" unhuman of individuals. To the rank and file of us to be esteemed is very much indeed, and to be generally despised is as bitter a cup as we are apt to have to drink. Says Edgar Wallace (as a chance coroboration of this idea), "The majority of crimes in the world are committed by people for the same reason,—they want to be well thought of. . . . Here is another gentleman who murders his wives in their baths in order that he should keep up some sort of position and earn the respect of his friends and his associates. . . . Here is the great financier, who has embezzled a million and a quarter, not because he needed money, but because people looked up to him. Therefore, he must build great mansions, submarine pleasure courts, and must lay out huge estates—because he wished that he should be thought well of." This motive at heart is physiological.

Our present concern with this "ruling passion" and "national characteristic" is that by its very purpose and by its location on the subjecto-ejective boundary, it is *clothing* which more often than anything else whatever furnishes the data on which the esteem of others, or their disesteem, is based. As Mr. H. L. Hillman of Boston truthfully advertises, "the clothes proclaim the man" (either directly or inversely!), and on their proclamation largely depends whether we are thought well of or ill. It is unfortunate, but undoubtedly it is true for nearly all our cursory estimation of one another in a crowded and busy world, too hurried to banish any accessible indication.

Fatigue, one of the most significant and pressing problems of psychology and of economics, has intimate relations to clothing in several respects. The details of the matter are too complex for our present discussion, and indeed the whole science, to say nothing of the art, of fatigue, weariness, and fatigue-prevention are in a formative stage from every viewpoint.*

In general, then, for present purpose it is enough to suggest that our day-clothes in general are distinctly and needlessly heavy, and confining and therefore unduly tiring to both the

* See Meyer Solomon's volume on the sense of weariness in the *Our Senses Series.*

body and the mind. Everyone who wears our kind of clothes (unfortunately the fashion is diffusing over the entire Earth) has felt the almost "delicious" relief of getting them off, thus allowing the body, if only for a few moments, to be *free*. Unrestrainedly to breathe both by lungs and skin; heart free to beat; and to move limbs and torso unhindered by a thick and hindering mass of rigid clothes to which the sensitive and easily fatigued nervous system as yet has not wholly adapted itself! The clothing-fatigue relations are complex and for some future detailing. It is something, however, to have in mind that clothes and fatigue are related, and importantly.

Sometimes, in some fashion-periods, the fatigue-effect of clothing, on women at least, amounts to a positive *disability*. This may be, and not very infrequently, a matter of life and death. Elizabeth Stuart Phelps, for example, in her "What to Wear?", writes: "When I read of the sinking of steamers at sea, with 'nearly all the women and children on board'; and the accompanying comments, 'Every effort was made to assist the women up the masts and out of danger until help arrived, but *they could not climb*, and we were forced to leave them to their fate'; or when I hear the wail with which a million lips take up the light words of the loafer on the Portland Wharf, when the survivors of the 'Atlantic' filed past him, *'Not a woman among them all! My God!'*—when I consider these things, I feel that I have ceased to deal with *blunders* in dress, and have entered the category of *crimes*." "These things" are being bettered the forty-five years since then; yet none too fast for a rational world.

A foot-note in this same book (1873) shows how much physical education has done: "Said a professor of elocution, of experience in the instruction of both sexes, 'When I first gave lessons at the Young Ladies' Seminaries, I was greatly puzzled. Some of my exercises are calisthenic, and require active movements of the arms. To my surprise, the girls could not meet their hands above their heads; many of them could not raise them half way to the required point. I was a young man, and did not know much about a lady's dress; and for some time the reason of this did not occur to me. At length I bethought me, that their mode of dress was at fault. I have been obliged to discontinue [!] entirely the use of those exercises in girls' schools, though I think them very important to an elocutionist."

3. *Relations of Clothing to Body-Temperature.* The third group of habilatory influences concerns body-temperature. Man is a "warm-blooded" (homothermous) animal and his success in living well is dependent on his maintenance of a fairly uniform temperature. People who have the intelligence (and the good-fortune) to avoid infectious diseases, may go through an ordinary life with no more variation than two or three Farenheit degrees during their whole time. On the other hand, a frog, (if we could think of his mind being deranged!) might have a variation of sixty degrees in the course of the six months between the end of January and the first of August. Like the other mammals and birds, we, then, are "warm-blooded," and have a very elaborate and competent apparatus for maintaining a relatively constant temperature whatever be the environmental conditions, or the (normal) balancing of energies and calories in and out of the organism. If this wondrous thermotactic mechanism be deranged, we have "fever"—or else "collapse." For the detail one must consult a treatise on physiology or on the applied physiology of exercise. Now with this thermotaxis our clothing has a great deal to do. In the first place, there is

A, The Texture of clothes. The base-idea here is that it is the layer of evaporating dead air next to the skin which makes us sometimes so uncomfortable. Anything, then, including a type of clothing, which will relatively prevent a layer of dead air from forming against the body will tend to keep us cool in summer, and, on the other hand, make us warm in winter. If anything will keep us cool in a warm environment it is the evaporation of sweat,—anything, that is, short of actual immersion in cool water, or in a rapidly evaporating breeze. The texture is the most important factor of this matter,—whether it be a close weave or a tight weave of modern loomwork.

B, *The Material* of clothes. Fur is warmer than wool, and wool than silk, and silk than cotton, and cotton than linen, and linen than darkness or just skin simply because, in the order mentioned, they retain a layer of "dead," non-conducting, air next to the living body. The material of clothes comes in very importantly then in that familiar way.

C, *The Color* of clothes. This is almost an art by itself in the attire of women. The basic principle in relation to the body-temperature, of course, is that white reflects the warming light and therefore is cool; and black is usually "warm," remember. White reflects and black absorbs the radiant energy—all understand that trite matter perfectly, and it need only be mentioned.

On the other hand, red excites, and thus warms. Red and all the bright colors excite, even green. Blue is the least exciting. Colors exert more influence on observers than they do on the individual. Black, on the other hand, depresses both wearer (by suggestion?) and observer; and yet somehow it seems for general use the most suitable color for dignified, responsible men and women. Many women look far less charming in any other color. Would that more of them effectively realized this fact!

The *mental* influence of the colors of clothes, in men as well as in women, have been more or less well worked out, but not yet in a psychological laboratory. It is obviously true, in the case of women especially, that there is no assignable limit to the mental influence of gowns, and of their gowns' colors in particular, on their emotional state of mind. Human dignity is often scared away by woman's fine and fashionable raiment; and nowadays a true gentleman of good taste is seldom seen in "colors." But it is, after all, only a matter of ephemeral "style," because up to a century ago the best of men wore the most vivid colors that could be made by fabric-dyes; and gloried in them, apparently.

Dinginess of color especially is not worthy, and therefore is of practical importance. Whether this dinginess come from the fading of dyes, especially "cheap" black, or whether it be an original, intended dinginess, dinginess is of considerable importance. This is not only because it can be seen further than any other common defect in clothes, but because it is a primary, conventional sign of the "hobo," of the tramp, the consistently "unsuccessful" man, of the "down-and-outer." It comes next to patches, "shreds and patches," as a sign of old clothes and of unsuccess. It is the first step toward structural and mental shoddishness, as all are aware. Dinginess shows a lack of proper color-appreciation when dingy clothes are bought new. Color has self-respect as well as other things have, and clothes-dinginess is a lack of color-self-respect,—as much so as habilatory color-saturation.

I had a little discussion last spring with one of my publisher-firms. I objected to the dingy color in which they had clothed one of my books,—a sort of "dirty" olive-brown; psychologically, no color at all. The head of the publishing firm wrote back that in their long experience the cover-color of a book seemed to have nothing whatever to do with its popularity or sale. I "put that proposition up" to another large publisher and he disagreed flatly, and said that from *his* wide experience they had learned that the color of a book has a great deal to do with its sale. The latter gentleman undoubtedly is right in the long run. Psychologically it could not be otherwise. The same principle exactly applies to the dinginess and other color-disagreeableness (dirtiness, for example) of clothing and still more importantly, although sale is not supposed here at present to be concerned. Yet a feminine gaudy dresser proves inevitably thereby her lack of womanly dignity, or else her racial lack of taste-restraint.

About the patterns of fabrics, I am not so certain. Of course, this too is a textile art in itself. Stripes and checks and diagonals and dots are all very important. Their psychology, however, is very complex, and it were wholly unscientific and therefore wholly unjustifiable to say very much about this matter until it has been worked out practically in some adequate psychological laboratory.

Obviously, dots strike or at least pepper one in the face. We do not need to be reminded that dots, large or small, (unless they are so small that you can't see them) are bad taste. But stripes, all manner of stripes, have an inconsistency, so far as their clothing-psychology is concerned. As I have found by inquiring of women, when the stripes run up and down they are generally supposed to make the individual seem taller. Based on experience, not on psychology, it has always been the tailor's theory that "a very tall man should never wear stripes."

One finds in almost any elementary text-book of psychology, however, two squares of exactly the same height, one of them filled with horizontal lines and the other vacant or filled with vertical lines. If one did not know that it was intended as an illusion, invariably he would be sure that the square with the horizontal lines was taller than the other. Invariably one would think that, and yet when he runs his eye along the tops of both, he finds that they are absolutely the same height. Here is an inconsistency between tradition and fact that I have not yet had time to "figure out," but scientifically it has some interest: Women assert very seriously that horizontal stripes make them look short and "dumpy," and yet, as a matter of pure psychology, horizontal stripes make a square appear taller. I suspect that other essential factors, some recondite, enter the costume-problem that are wholly lacking to the drawn squares. Suggestion probably is one of these other factors, from deep in the traditional subconscious feminine mind. But perhaps habilatory horizontal stripes make their wearers seem to them wider and so proportionally shorter, because the critical women observers look so hard and vigorously along the odious stripes that the exaggerated kinesthesia quite overwhelms the more accurate comprehension of the retinal proper,—psychology familiar enough. However, the matter is one of relatively small account, stripes now being uncommon and out of style heaven be thanked!, even in the prisons since Thomas Mott Osborne and others have shown us anew their inherent criminality to their victims. Later on, when these jail-stripes have wholly gone and been forgot, stripes will doubtless become fashionable for less blameworthy but freer women and men—for it is just this kind of suggestion among others, which determines, or helps to do so, widespread and relatively long-enduring modes, as has been seen over and over again.

III. SOME APPLIED PSYCHOLOGY

We come now to the more purely psychological aspects of clothes-science so far as I have been able to dig them out from the concatenated nature of our pragmatic personalities. Quite plainly, the expensive research required to adequately develop to its inductive ideal the science of raiment is at present wholly inexpedient, but it is to be anticipated that the extensive makers of clothing and of gowns will be eager to finance this scientific undertaking when its interest and practical human and economic importance have been appreciated.

The psychology of the ever-changing *mode* has been somewhat adequately studied, and hundreds of volumes, probably, have been printed to set forth the dramatic history of costume and its substitutes among mankind of both cultured and savage races of men. Some of these are folios and beautifully illustrated; some are in Latin, and deal with the efficient clothing of the ancients, especially the Greeks; some cover the entire human range from the savage up to the date of composition. Most of these histories of costume are national in their scope and show how intimately clothes and racial history are interwoven. Perhaps the most important of the American treatises is that of Alice Morse Earle dead all too early, who has done very much for American patriotism.

So far as the writer has been able to learn, G. Stanley Hall, keen biopsychologist, was in 1905 the first to approach the psychology of clothing in a sociological questionary, summarized and somewhat oriented and discussed by L. W. Flaccus in 1906 (see list of references at the end). This paper is entitled "Remarks on the Psychology of Clothes," a name commendably modest but on the whole just. The conclusions are various, and for the most part suggest the concensus of the remarks which one any day may hear from a group of women (or from some types of men) when talking about their costume. The questions employed were grouped under fifteen heads, and run as follows: "1, How does a sense of being well dressed or the opposite affect you? How are you affected by shabby or illfitting gloves or shoes? 2, Do you feel a change in your personality, and if so describe it, from being (a) in conventional evening dress (b) in an outing costume which gives unwonted freedom of action? 3, Do the materials of your dress affect your feeling, i.e., whether they are filmy soft stuffs or stiffer and more unwielding materials? Do you like the rustle of silks? Does the wearing of fur have any special effect upon your mental state? Does the character of your hat? Do you like to wear a train? Why? 4, How does the presence of some defect in your clothing, which may not be obvious to others, affect you? Are you conscious of a difference in feeling due to fresh, dainty underwear, irrespective of external dress? 5, Are you particular about the fit of your clothes or to have them of the latest style? Have you special preferences for certain articles of clothes, e.g., hats, lace, jewelry, fine gloves or shoes, handkerchiefs, pins, neckties, etc., so that any extravagance in dress is apt to be in that direction? 6, What is your feeling toward imitation lace, jewelry, etc.? 7, What proportion of one's total personal expenditure do you think should be devoted to clothes? 8, Children usually like to "dress up." Did you do this when a child and in what lay the enjoyment of it? As a child were you particularly conscious of your clothes, and to what influence would you attribute this? 9, How are you impressed by the dress of others? Does it affect your estimate of a person and if so in what ways? 10, What individual tastes and preferences do you sometimes indulge that are at variance with fashion? 11, What can you suggest about the care of clothes and its educative value? 12, What do you deem important in the care of nails, dressing the hair, cosmetics, face-washing, etc.? Can cleanliness be excessive, and what about exposure of certain parts of the body, both in society and to sun and air in summer—going barefoot, gloved, bareheaded, etc.? 13, What reforms in the dress of men, women, and children would you suggest, and what about too much or too little clothing? 14, What about ornaments and adornments generally? 15, Say something about canes, parasols and fans, and also state any experience with masks, masquerades, theatrical costumes; the *lies* of clothing, e.g., padding of all kinds, fits, pinchings, tight fits, and loose flowing raiments, and what changes are natural at different ages and periods of life?"

One hundred and eighty-one sets of answers came to these questions from a normal school in New York State, the sex of the writers not being stated. "Because of the very limited number of answers," says Flaccus, "little would be gained by working up the material in percentage form," but he points out some of the interesting types of answers and some individual replies, after he has arranged them in three groups: "1, minor and incidental matters, psychological tidbits, etc.; 2, changes of feeling, fluctuations and changes in personality, differences in feeling-tone, diffusive and expensive effects; and 3, effects on the self as a social reflex phenomenon."

Little is to be found in the answers discussed concerning the physiological psychology of clothing, but what there is undoubtedly corroborates Lotze's keen hints, already related above. Little, too, is to be found in Flaccus's report concerning the interrelations of our clothes and our *cenesthesia,* basis in a way and in a degree of our behaviour and a continual influence over our wills, especially when unrealized and therefore unopposed by conscious effort. Clothes in several important respects are the frontier of our environment; but no less are they powerful determinants of our own inner consciousness. It is here, and in the raiment's direct relationships to our ejective, social environment, that lies the future applied psychology of clothing whenever facilities shall be afforded toward the unravelling of the numerous problems which President Hall's questions so interestingly suggests.

Please remember that the mental influences and the practical relations of clothes, in all their complexity and force, begin at birth, nowadays, even in state wards and in some institutions for children. The influence then received always is lifelong; it is absorbed with the mother's milk, so to say; in the home it has strong motor emotional tones from the first. Quakers are a noteworthy exception to this rule; they have it as one of their fundamental tenets and attentions that they will not pay any attention to clothes, and relatively to most others they have always succeeded, and doubtless will continue to do so. And the convict's extreme interest in his shameful clothing is happily now a thing of the past, or as obsolescent as the lash.

But interest in clothes, verging into vanity, comes in our ordinary life from the very "first" day, and maternally long before. That is one of the reasons, scientifically, why it is impressed so deeply and so emotionally on the dynamic subconscious mind of young people in general. The children who are not by their own initiative victims of too much clothes-consciousness usually feel it and hear about it in others, and so the effect is about the same. Clothes-consciousness is relatively insignificant in childhood, notwithstanding all this influence. The exceptions are a certain "type" of little girls.

This consciousness so far as it relates to the inessentials of the art of dressing, leading through habit to personal vanity and sundry kinds of fixed ideas, is of course an evil thing for the child, for it narrows her interests and tends to wrong the growing ideals of personal beauty which are at heart properly anatomic and physiologic.

On the other hand, rightly directed, dress-consciousness becomes but a part of that universal awareness of body, which elsewhere* I have already praised as an universal cenesthesia,—the only firm foundation for that self-knowledge on which valid education and efficient worthy living possibly can be based.

But in either of these two cases, the clothes-consciousness of the child, even if it be mostly negative, a negation of the desire, constitutes the firm and life-lasting foundation for the phenomena of clothes-psychology which begins to be so conspicuous with the florescence of the personality at puberty:

In the more physiologic part of our discussion we have seen that clothes serve sundry protections, just as the skin does: the "box-coat" of the tortoise, the quills of the hedgehog, the feathers of the robin, the armor of the sturgeon, the colors of the

* *The Mother's Magazine*—eight articles on habit and on early sense-training, 1917-1919.

flounder, are all examples of clothes, we might say, in the lower animals, which serve as protection, very important, indeed quite indispensable protection, of various mechanical and physical kinds, giving them more freedom. And I tried to make it understood that especially *freedom* is served by our own armor, our clothing; freedom from various things which are various forms, in short, of fear. We may note without danger of being successfully contradicted, that clothing at one time or another, in some people if not in others, protects us against fear: *fear*
1, of ridicule; 2, of the estimation of poverty; 3, of the estimation of inefficiency or stupidity; 4, of numerous dermal discomforts; 5, of bodily internal discomforts; 6, of the esitmation of bodily immodesty; 7, of anxiety; 8, of the estimation of a lack of self-respect; 9, of the estimation of a lack of good taste; 10, of obtrusiveness; 11, of an under-estimation (real) at "first impressions"; 12, fear of the estimation of homeliness or lack of the desired beauty.

Many of these fears, it is obviously true, are subconscious. It is not easy, however, to believe that clothes could mean so immensely much to so many people, unless underlying its applied psychology were some emotionality which takes a tensely gripping hold on the deeper being of the individual. For instance, snobbery is not valid. Emotions other than fear, (notably vanity, modesty) affect the wearer of clothes in any social environment, but I believe that the moving emotion, the actuation, is fear more often than any other; and at heart always self-protection.

Fear certainly mostly underlies the psychology of clothing as it does the psychology of other important features of our common social life. I should like, if it were necessary?, to enlarge on this super-importance of fear generally in our daily life, for there is no one thing in this astounding world that the vast majority of children and of men and of women need to be relieved of more than of the various kinds of dread, worry, and fear. Fear is one of the very worst enemies of our race's civilization as well as of our personal comfort and moreover of our efficiency. Why fear (as Morton Prince has shown), has made the megalo-maniac Wilhelm II into a beast—fear of losing his anachronic "job." But really nowadays one does not need to enlarge upon this matter, for the whole consistent trend of modern psycho-therapeutics, of "Christian Science,"' and of all the other aspects of mental influence, is striving its best to coax or to drive fears of various kinds out of people's minds. And the most important aspect of fear, of course, is worry, a chronic, but a none the less harmfully powerful, form of fear.

Protection and relief, then, from such fears, in addition to those that I have already mentioned of a more physiological nature, I take to be la raison d'être, the real aim and purpose, of the wearing of clothes. And that is of importance.

Now, fear is so instinctively and yet so unpleasant a part of each unique conscious individual, that relief from it in all its phases often is a positive and a lasting joy. I wish to call especial attention to this familiar proposition, that to be relieved of fears of various kinds is not only a negative thing but sometimes in some natures a source of *positive satisfaction,* of conscious delight and contentment. My hemobarograms show this. Then add vanity; self-confidence; pleasant anticipation; satisfactions with oneself; and other emotions; and we have the strong, pleasant emotional tone which lends to some persons the tremendous energy and "pep," so to say, the *desire,* always to be "well dressed." But as we have seen, after due consideration the essence of the psychology of being well-dressed seems to be statable scientifically as preponderantly *a relief and protection from various kinds of fears.*

Clothes-fear is none the less powerful and effective as a motive because often subconscious. Sometimes the individual is wholly unaware of it, but on that account it is none the less cogent and practically important. Fear, obviously, of this kind, relating to being not well-dressed, is more subconscious in men and boys than in girls and women. That is to say, most women have more consciousness of being ill-dressed or well dressed than have men. It is part of their blessed nature, and rightly so. The vast biological purpose and use of the desire to be beautiful, and even self-assertive, on the part of the female is plain to all, but worth noting, and withal worthy, too. The same conditions obtain in the male, but in a far less degree of consciousness and of inconsistency and of importance. Perhaps in many self-reliant men it exists in too small a degree; many men after thirty years need in some way to be aroused to pay more attention than a great many of them pay to their personal appearance and success-index so far as clothes are concerned. And so too they would attract womanly young women of sense more certainly yet, frequently to the common benefit.

Those who have been brought up in university communities have occasionally seen men, often philosophers in the philosophic departments, or deans of colleges, who would disregard this whole matter. Diogenes, or Cleanthes? None the less, a large majority, of course, even of academic people and of "bookworms," pay due attention nowadays to this matter.

Being well-dressed, then, is part of the essential ratio between happiness and personal ability and efficiency which I am continually trying to emphasize. The practical value of contentment, indeed the whole matter of contentment and of physiological self-satisfaction, are worthy of notice. Fear, conscious or subconscious, ordinarily maintains, even at great and varied cost, this contentment, and at times almost instinctively. Contentment, rational self-satisfaction, has its roots extended into nearly everything in life.

It is related, for example, very closely to love. In a recent novel ("Troubled Tranton") by W. E. Norris, published in 1916, in England please observe, purely by chance I find this statement:

> "—she had really loved him almost from the very beginning. From the very beginning, at all events, she had had a feeling about him that she had never had about anybody in the world before.
>
> Asked what sort of a feeling, she replied: 'The sort of feeling that one gets when one's clothes fit absolutely. It's a rich and rare sensation, but you wouldn't understand it, I suppose.'
>
> He understood well enough to be wildly exultant, and for a minute or two, as eloquent . . .," etc., etc., etc.

This is a rather striking illustration to come from a novel written by an English literary observer and therefore really a "knock," quite unscientific but certainly timely, on the highly commendable lack of tightness in the average tailor-made clothes of English men and women. This recalls in like manner the feelings of the fine lady of intelligence who assured Herbert Spencer, as his diary tells, that the consciousness of being perfectly well dressed gave her "a peace such as religion cannot give" (E. A. Ross).

And comfort, I have tried to show, is indispensable to a high efficiency, and I must not allow you to forget or to mistake that point. It isn't merely a matter of creature-comfort, but it is a matter of efficiency as well, and efficiency both physical and mental.

Fitness. "The sort of feeling that one gets when one's clothes fit absolutely," as Norris puts it, (and he is a close observer and withal a *man*) comes only from "fit"ness, from an absolute fit, not tightness. We need next see what that means, as applied to clothing, for the term might easily mislead. To me, two criteria are essential, one of a general and the other of a particular nature. First, a uniform snugness with a reasonable amount of looseness for the organism as a conscious and living and variously active "machine" with vital and mental processes to carry on, within the clothes. We have already discussed this matter of body-fit and how it is compatible with a uniform looseness.

Second, fitness to each unique *individuality*. As has been pointed out, fit appears to be very well brought about in a fitting of clothes-types. At least ninety-nine out of every hundred not-deformed men could be fitted by a reasonable number of well-developed factory-types of clothes, and I believe better than the *average* custom tailor would accomplish it for each unique individual. There is a relative fitness for his clothing, (uniform snugness so far as compatible with an equally uniform looseness!); general appropriateness; above all, appropriateness to the personality; and this usually (see below) involves a relative

Unobtrusiveness. Indeed that is the next point I wish to emphasize. An essential thing about a well-fitting suit of clothes (remember we are not talking solely about the body any more, for clothing must fit the dual, the multiple, personality), an important element of fitting a personality, is that it must be unobtrusive. That is my idea of a well-fitting suit of clothes: one which fits and is unobtrusive.

Obtrusiveness. Of course there are exceptional people in whom obtrusiveness is a necessity made a virtue. The clergyman, the detective, for example, the prostitute (see Robert in our little bibliography), the hospital-doctor, the "sport," the politician, the butler, the army-general, the nursery-maid, the policeman, and a great many others, all wear clothes which should be obtrusive; their clothes' business is to be so. The widow wears her sombre-colored clothing, the sport his flashy checks, the cruel "Boches" their pointed helmets. The cassock of the priest; the ultratightness of the clothes of the dude; the mere startling surprises of the female fishers of men (whether as husbands or lovers or both)—all such are a variety of "sandwich-men" with their business glaring front and back.

Self-confidence is another form or aspect of the essential satisfaction arising from clothing-fitness. Protected, fearless initiative; unirritated, mind-free, normal manhood and womanhood, confident of its eternal and universal mastery, arise from rational self-satisfaction. Clothes help this in no small degree,—or hinder it. "Success" has as one of its conditions a self-confidence, a fearlessness, and success in general usually is not probable without that self-confidence, this eye-to-eye fearlessness of general criticism.

Several writers, for examples H. Addington Bruce, the well-known psychologic writer, and Bruce Barton, recently have called popular attention to this very practical relationship between success and self-confidence and wellfitting clothes. *"Success" and clothing are inter-related.*

Adequate clothing and success. From my 1917 summer-school class in psychology at Harvard, men and women, twenty-four of them, averaging twenty-eight years in age, there are answers to the general question, Why are "success" and clothing inter-related? There are seventy-eight answers, made up of thirteen different reasons; the replies were written out carefully, but spontaneously. (This summary of these reasons was kindly made for me by Miss Winifred D. Muhs of the Chicago Public Schools and two of her friends, to whom I extend my compliments and thanks.)

A well-dressed person more easily gains the confidence of people in the business world. *Fifteen* answers said practically that.

Consciousness of good personal appearance frees the individual from the fear of the most common form of adverse criticism. *Fifteen* also said practically that.

The personality of an individual is judged, first of all, by his external appearance. (That is absolutely inevitable.) *Eight* replied thus.

Those habitually well-groomed carry that neatness to things beyond clothing. (It suggests a neatness which is sure to be applied to other things.) *Seven* said this.

Social advantages are frequently obtained as the result of pleasing personal appearance. *Six* gave this reply, in substance.

First impressions are lasting with many individuals. *Five* suggested this.

The appearance of having money carries with it the impression of the power to make money. *Five* said so.

To see an individual well-dressed produces a pleasurable sensation in others and puts them in a favorable mental attitude toward the individual. (Empathy.) *Five* answered thus.

Being well-dressed has an unconscious effect on the carriage of the individual, and conversely a good carriage promotes a desire for good clothing. *Three* said this.

Being well-dressed has an effect upon the emotions of the individual, such as joy, ecstasy, etc. *Three* answers.

Clothing often reflects the habits of living, such as home influences. *Two* suggested this.

Being well-dressed requires a certain amount of cleanliness, therefore is hygienically worth while. *Two* gave this idea in answer.

Half the world is being bluffed by the other half; dressing well helps your bluff. *Two* answered in that way, both of them men.

Miss Muhs almost summarized the whole matter, and especially well from a feminine viewpoint, by one of her own answers: *"If you feel right, you can get good results."* Two implications come from this intuition, both good clothes-psychology: If you are well-dressed you will "feel right"; and "success" depends on getting "good results." The conclusion is various, but interesting.

Now those are answers to the question as to how "success" is aided by clothes, from young men and women, mostly teachers. They probably represent the unbiased opinions of people who have no immediate special concern with clothes in any way, aside from what every one (hereabouts) has.

Appearances, remember if you please, may rise far above the reality. One's clothes may be far better than his soul, his mentality, his body, or his bank-account. But none the less, till every lass and madam and "man Jack" is a philosopher, and a Stoic philosopher at that, the wise man in an average social community will not ignore appearances,—unless, at least, he be well fixed above that community.

It is certain that the philosopher, even the amateur philosopher, can rise above his clothing. It is still more certain that philosophers (Zenos and such) are scarce, not to say rare and obsolescent and very nearly extinct, so far as practical affairs are concerned. One sees them oftenest perhaps in the modern representatives of the secular hermits, the men who live secluded lives more or less *alone,* and therefore tend to lose the clothes-consciousness with the clothes-fears and the need of protection. This relation of adequate personality-fit of one's apparel to his "success" from the "low world's level stand," involves many principles of human nature and of human personal and social motivity. They will gradually be worked out, but not here.

First appearances and "success." For any who doubts that clothing is related to "success," I report some typical and actual cases. I asked the members of one of my classes to recount actual personal or observed experiences in which the being well-dressed was of actual benefit, actual aid or the contrary, to success. I venture more or less exactly to transcribe a few of these instances from "real life":

A young woman: "I was to have an interview in —— in reference to a position as instructor in a settlement-work home there. I wore plain tailor-made clothes. The lady was evidently impressed by my appearance. She had never seen me before, but before leaving for Boston, she offered me the position as "director" in the institution, and writing to me afterward, said: 'Your tailor-made appearance as you stepped from the train made more than a pleasing first impression; it was indeed a striking one,' etc., etc."

Here is another: "I know two young men, one in particular, who is not at all sincere in any work, who is always losing his positions but who always obtains good ones. He ever makes it a point to be well-dressed and groomed when seeking interviews, and his dress and pleasing manner always 'land' him a place."

Another one: "The experience I had was in applying for positions and in that I heard that, on account of my being well-dressed as it was termed, meaning by that a medium apparel, tailored not extravagant, nor yet slack. The Faculty and Board thought the influence I might have on high-school girls to do away with the present-day foolish desire for display would be as great as the physical training. Impressions made on first appearance are often very lasting and very important for the applicant. If one is careful about appearances, employers can nearly always be sure their work will have the same care by their employees. Clean-cut people are always the winners and nearly always demand attention of others."

Here is another: "I recall a teacher who, though she paid high prices for the articles of clothing that she wore, but who did not dress well, tasty and neatly, was without a position for a number of years."

Another: "A teacher applying at the —— Agency in person was so suitably dressed and harmoniously with her own personality, that she was offered the position on the spot, apparently regardless of recommendations, etc., by the Superintendent who happened to be watching."

Another one: "My brother in 1911 secured a position with an electrical company in competition with six other men who were graduates of the same institution as he. The manager afterward told him that he was chosen for several reasons, one of which was the fact that his personal appearance, clothes, and general make-up were more pleasing than that of the other men."

Another: "Two years ago I was asked to make personal application for a teaching position. I considered that my obtaining the position was partly due to the fact that I was well-dressed. My suit was smart and becoming in color. All accessories were in excellent taste and the whole effect was good. I am sure my appearance impressed the Superintendent, for he asked me very few questions regarding my previous experience or present qualifications, but hired me almost on the spot. I know that I was never less self-conscious nor more sure of myself."

"As a child of nine years," says one, "our teacher always chose the best-dressed pupil to run her errands to other rooms in the building. In those days little girls wore aprons but there was one among us who wore fancy dresses and bobbing curls." She was usually the favored one "except where some of us would appear for the first time in a new dress—not covered by an apron. I did not realize the significance of the attractive dress until a few years later."

Another: "In Kansas the Board of Education depends a great deal on personal appearance in selecting their teachers. They must all visit the town, and as good clothes cover a great many faults—if they make an imposing appearance they are generally taken on that basis alone. They want a model for the pupils and I have known them to turn away a woman with a sloppy appearance."

Another: "Saw an experience in an employment-bureau some years ago while in town. There was a large number of applicants of various stages of prosperity, judging by clothes and general appearance. The proprietor or manager singled out a young man of about 20 years of age, because he was well groomed in personal appearance and his clothes looked clean and well cared for. There was no other reason to choose him first from the waiting crowds except his general appearance of personal care."

Here is the case (of almost historic interest in Boston and in New Hampshire) given in "Every Week" by H. Addington Bruce, in September, 1916.

"A good many years ago there arrived in Boston a young man whose total capital to begin business life was less than five dollars. Naturally, this did not carry him far; but it did carry him to a position as oyster-opener in a little all-night restaurant. Here he made the acquaintance of a 'night hawk' cab-driver, who became very friendly with him and promised that he would 'tip him off' to a better paying place at the first opportunity.

One night the friendly cabby gave him the news he had been anxiously awaiting.

'I've got another job for you,' he announced. 'They want a man behind the bar at a hotel where I have lots of friends. The job is yours for the asking.' And he named one of Boston's leading hotels.

The young oyster-opener handed in his resignation, and hurried around to the hotel. The hotel manager, after one cold, appraising glance, curtly told him:

'I've got nothing for you. Yes, a man was wanted; but we don't want anybody now.'

It took the over-confident young man nearly a month to get back his too hastily resigned place in the restaurant. Meantime, if hungry and homeless, he used his eyes and ears and his mind to good advantage. Accordingly, when the cab driver a little later informed him again that a man was wanted at the hotel where he had already applied vainly, he did not rashly resign the place he held. Instead, he asked for a night off, and hunted up an acquaintance, a man of about his own build, but more prosperous.

'Jack,' he said, 'I want you to lend me your Sunday clothes, walking-stick and all.'

Next morning, after a good night's sleep, well shaved, and dressed better than he had ever been before, he called once more on the hotel manager. The latter, needless to say, did not recognize him.

Politely he inquired what he could do for the well dressed stranger, listened attentively to his application, and expressed regret that he had nothing suitable to offer him.

'But,' persisted the applicant, 'I understand that you want a man behind the bar.'

'That is true. But it is not a place that would suit you. What we want is a man to clean glasses and get rid of empty bottles.'

'I'll take that place. When shall I begin work?'

This, I say, happened in Boston a good many years ago. As time passed, the young man prospered until long before his death, he was the owner of several big hotels. One of these was the very hotel where he had begun work as a glass-washer. You may be sure he never forgot that he owed his start in the hotel business to the wearing of a good—if borrowed—suit of clothes."

Many of my readers have seen and enjoyed the clever and interesting comedy, *"The Tailor-made Man,"* developed by Harry James Smith out of Gabriel Dregley's "The Well-Fitting Dress-Coat," and ably staged by Cohan and Harris. The cost of seeing it in money, bother, and time is a capital investment not only in delight, but in applied psychology as well.

Just usefully to exemplify the important scientific principle that there are two sides to everything (unless it be a mother or a geometrical point) we may quote the only expression of doubt offered by my students. (Several others said they had had no experience of relation between clothing and success.): "I don't know personally of any case at all where the clothes have been the cause of a person's success.—It's usually the personality of the person that gets them by. I happen to know of one man who came up to Harvard from somewhere down South. He was about as poor as a church-mouse and if personal appearance had had anything to do with it, he wouldn't have gotten very far. His college life was successful—won scholarships and all sorts of things for his work. Also a very successful position in a law office. But I would call it ambition, personality and stick-to-it-tiveness, not clothes." It may not be wholly unscientific to suggest the conjecture that the clothes of this Harvard man "from somewhere down South" were a not inconspicuous and successful factor in that personality, which according even to the second and more immediate summer Harvard-man is what "gets them by,"—whatever that may mean for psychology.

Now those are actual illustrations which may serve as well as many more from any number that might be obtained, to emphasize that, in the estimation of most people, to be well-dressed is a distinct aid even to practical dollar-and-cent success. For a wider and deeper personality and its better values, nothing further need be said, for all recognize freely the meaning of the pragmatic "me."

First impressions really are of great practical importance because as "beginning stimuli," sudden excitation, they impress the mind very strongly, and then through continuous action of the subconscious gain permanent influence. Physiologically, we have here a contrast-effect, a change, and a sudden one, in the environment (Verworn). We have the vigorous impression that comes from something wholly new and perhaps striking, striking certainly in the sense that it is the first impression obtained of that individual, making the base-neurogram in the cortex. Perhaps this is stronger, the first impression, in women-observers than in men. Perhaps in them, too, it is more intuitive and more emotional.

Therefore is it that wives and sweethearts are the proper chaperons of men when they go to buy their clothes, whether made or to be made. This is something that perhaps is well worth consideration: that women in general are very much better judges of well-dressed men than men are,—than they themselves, the buyers, are. And if the industrial side could in some way educate men actually to trust to their wives and sisters and sweethearts and mothers or even aunts, as to when their suit is fitting or not—*fitting* to the personality, remember, not to their body only,—it would be a distinct advantage in the securing of satisfied customers, and thereby of a better-dressed public. A woman is the ideal arbiter of manly clothing.

Most women have distinctly a faculty of "sizing-up" an appearance, especially of a man, which rests on their intuitive faculty, a power which in its quick and subconscious form men for the most part lack. Men are reasoning creatures, but women can go through the reasoning process (as I have recently pointed out* anew), only they do it very quickly sometimes, and instinctively; but regularly it is just as accurate a product, and oftentimes far more so, than that which the man slowly could work out by that which we call reasoning.

Uniformity, save of uniforms, is a crying wrong in general in our system of dress, but it is less true of women perhaps than of men. Among the more indigent people (with an apology to Kipling), we may say:

> "They are like as a row of pins,
> For the Colonel's lady an' Judy O'Grady
> Are sisters [over] their skins,"

as well as "under." There might and should be far more personal latitude given to clothes. Instead, there is slavery to set styles, partly because of extensive factory manufacture and partly for the very different reason of adherence to the very latest mode.

Dress-making is a typically feminine high-accomplishment; and properly speaking, as a matter of theory, each womanly woman might well make her own gowns and accessories, thus giving them a personality-fit in its logical limit of perfection; an uniqueness exalting to the unique personality making and wearing the clothes.

As I see it, the "house" that provides the men's clothing that will best fit the vast majority of personalities, in the long run is going to get more than its proportion of the business. On the other hand, the unobtrusiveness which is so essential in a well-dressed man and woman is sure to be lacking in a general servility to style and fashion. On the third hand, again, over-uniformity is sure to lessen the individuality in more important respects than clothing suggests, often, however, at a great common benefit.

Uniforms in general for soldiers, policemen, firemen, sailors, etc., are clearly much more than a symbol of the quite indispensable esprit de corps. The uniforms one might almost say ex-

* "Intuition," *Psychol. Review,* XXIII, 6, Nov., 1916, pp. 465-483.

press the esprit de corps; they certainly preserve it. One cannot imagine an army, in these days, at least, (but recall the "Minute-Men"!) that didn't wear uniforms. The clothes of the private individual should be unobtrusive but should not be uniform, just as the individuality is sacred beyond any greater "unit," because every conceivable such unit exists only for the furtherance of the individual; on no other base can Democracy, the Vast Cry of this urgent period, stand and endure.

Evening-dress in the case of men is essentially uniform, and a uniform, although made of broadcloth instead of olive-drab cloth. As such, the wearing of it tends, and to a degree often noticeable, to merge the personality of the real man in a kind of unreal snobbery and pretense of class or group, in this case "fashionables" or would-be-fashionables. Present evening male dress therefore is condemnable not only for its somberness and supposed stiffness and (frequently) tightness, but because of this unscientific uniformity which makes for impersonality precisely when the one thing important beyond all else is unique personality, the *man*. He is something usually worth while when encouraged to be in each case his own self rather than a fashionable in fashion's uniform. Better the mess-house garb in the lumber-camps of Newfoundland! Personality is there.

The all-pervasive Burton's "Anatomy of Melancholy," antique store of erratic wisdom, 1652, observes, " . . . now most men are esteemed according to their clothes. In our gullish times, [Cf. 1918] whom you peradventure in modesty would give place to, as being deceived by his habit, and presuming him some great worshipful man, believe it; if you shall examine his estate he will likely be proved a serving man of no great note, my lady's tailor, his lordship's barber, or some such gull, a Fastidius Brisk, Sir Petronel Flash, a mere outside. Only this respect is given him, that wheresoever he comes, he may call for what he will, and take place by reason his outward habit." And certainly is this last statement true in 1918 as in 1650 to a degree not supremely complimentary to the sincerity and ideals of human nature. First impressions prevail. And Burton again, but in regard to women's dress this time, quoting from Ovid:

"Auferimur cultu, et gemmis auroque teguntur
Omnia; pars minima est ipsa puella sui."

It would be interesting to hear old Ovid's opinion of some of our contemporaries who have developed camouflage (not to say plain padding), apparently to its somatic, if not to its logical, limit, yet moderated in essential details since a century ago, even if developed in other respects.

Deceits in clothes (aside from the adulteration or the substitution of their materials) have been numerous and are in some ways of much interest. Padding is an old aspect of it and usually has as its aim (save in deformities) apparently, the heightening of sexual attractiveness; one thinks of the broadened coat-shoulders of the male as quickly as of the bust-extenders of the female or of her hip-pads.

A peculiarly subtle sexual camouflage that I have recently noticed is a complete set of unbuttonable buttons and buttonholes down the front of a silk shirt-waist, the garment being properly closed by concealed means beneath. The psychology involved in such a device for producing situations suggests beautifully how the science is permeating even the most commercial phases of society!

But the deceits of clothing would require a monograph for themselves to be adequately set forth and analyzed.

The really well-dressed persons in general wear clothes which are not easily differentiated from the rest of their personality at all. Indeed, philosophically speaking, one's selfness includes all of his relationships. If you please, this is a matter of good philosophy, not merely a matter of hearsay, that a man's personality is absolutely all of that man's relationships, what James pointed out as the pragmatic Me. The psychology of clothing emphasizes it, as it is not hard to understand. *Naturally,* in a social community a man's clothes are part of his very self. It is a worthy philosophic proposition. Clothes are not something that he puts on and may wholly take off; a parasite that bears no relation to his personality. The clothes a man wears are really part of his personality considered from a common-sense (the pragmatic) point of view. Therefore, they should fit into it as well as on to it. They should be for whom they are made unobtrusive. They should be part of the individual. And then, properly and socially speaking, they *are* part of him.

Thomas Carlyle in his classic "Sartor Resartus" delineates this symbolic aspect of raiment once for all, but the work as a beautiful whole deals with man, not with man's clothes. But this symbolic aspect of our raiment may not profitably be ignored.

Fine, expensive clothing implies wealth of the wearer or else the having of wealthy friends; and well-fitting clothes in like degree imply taste and culture. Therefore, to the cultured and the wealthy, fine and well-fitting clothing is right and normal. "Costly thy habit as thy purse can buy." By the same token, however, it is a means of pretense to many who are neither cultured nor rich, but who are not positively adverse to being thought either, or even both; hence frequent gross extravagance.

Initiative. The self-respect and self-confidence which seem to be, in fact, (however loath we may be to accept the fact), partly dependent on clothes in some persons, and in some persons largely so dependent,—this self-respect and this self-confidence are intimately part and parcel of the essential *initiative* of every individual. Initiative stands for strong personality. If a man has not self-confidence, he will not have initiative. He will not "start" things; nor keep them going. He will not have that self-confidence which is the necessary preliminary to normal success. He won't try to do things. With self-confidence, he is apt to have a larger amount of initiative. In my deliberate opinion self-confidence for the great mass of men and women is to some extent obviously dependent on being well-dressed. My own introspection when "all dressed up" (and somewhere to go) emphasizes freedom from the obsession of clothing, leaving a chance for untrammeled initiative. The "peace that religion cannot give!"

I have tried to emphasize already and perhaps enough that *self-confidence actually is part of the energy and the efficiency* of the individual. So is this feeling, true or false!, of being of some account in the world and on an equality with the best or even with the richest! And even if a man is well-known to be indigent, a down-and-outer even, if you will, a rather large per cent of men and women, as a matter of fact, will take the counterfeit at its face value, for snobs are not only snobbish and most despicable, but often shallow and insincere even at that. The snob sees no deeper into a man than his underclothes, at farthest.

For the most part, the "hobo," the truly down-and-outer, does not appear even among snobs well-dressed; and only rarely is the highly "successful," (that is, merely rich) business-man positively ill-dressed however much of a philosopher he may be. For practical business purposes, then, clothing certainly does, as Mr. Hillman says, "proclaim the man." There is no doubt of it, and the numerous exceptions are not relatively numerous, but only seem so because we notice the sartorially exceptional cases and seldom the vast majority of the well-dressed, because, as we have seen in the philosophy of dress, these are unobtrusive.

To young people and to middle-aged people the clothes proclaim the man more exactly, of course, than to elderly people, who, wiser and broader oftentimes, realize how inexpressibly complex are human social nature and human motivity, and so look for more caprice in the matter of clothing than their juniors allow for.

The *discomfort* of ill-fitting clothes may not readily be exaggerated. Personally, although custom tailors have made my clothes since I was fifteen at least, I know that the sum of the clothing discomforts is very considerable, and of very great practical importance; that is, as far as constructive mental efficiency goes, at least. My continual aim, save when in the cold, is to get offending garments *off* as soon and as much as possible. Coat-collars behind may be too high; waist-coats too tight; or too short; trousers too waistly tight; their legs too long; the arm-holes too small; the coat-sleeves too long; and an irregular fitness all over the body. Then add scratchy hard collars and tight shoes and hot hats and squeaky shoes and ephemeral socks and ill-fitting underwear, and it is certain that to a man or woman whose efficiency is closely related to his freedom of mind and to his relative comfort, the clothing-matter is one of much importance. The multiform discomforts of clothes are an important economic factor, one worth attention from the consistent economist.

Pockets numerous and roomy that may be freely used are noteworthy features in truly comfortable and efficient raiment,—as many officers in Army and Navy service recently have learned through their enforced negation. Few women know what they miss by their stinginess in pocketry.

Purely, of course, as a rough judgment, I believe that the discomforts of people of relatively free efficiency that come from ill-fitting clothes, in various ways, detract very considerably from their *practical* efficiency. As I look back over my work-hours and see how very many of them were disturbed, not to say spoiled, by various kinds of discomforts of ill-fitting clothes, of one kind or another, I judge that on the average, fully ten per cent of inefficiency may come from the lack of proper, that is, primarily, comfortable, clothing. We will now say nothing of the unhappiness itself, although we have an inherent right to contentment,—and to happiness, if we can reach and keep it!

Personal bodily modesty is a clothes-topic whose psychology and sociology scarcely need discussion in our little *Sartor Resartus Dissectus*. It is simple and sad enough: the young women and even the no-longer-young women use their clothing as well as their lack of clothing to advertise their bodies. No one has discussed this more ably, perhaps, than Professor Winfield Scott Hall, well known for his widespread lectures (and booklets) on social hygiene as well as for other important things. He points out that a young woman should use her clothes, if at all, as part of an attractive and love-worthy and marriage-worthy personality,—never in such ways as to advertise her person. This logical and psychological opposition between persons and personality seems to be the keynote of the whole sex-modesty matter in its relation to clothes. (See Havelock Ellis for the anthropology and the psychology of the subject, in the reference-list below.)

The base-principle of this matter is that clothing has created the concept-feeling complex which we designate as immodesty when used in reference to nudity and to naked human bodies in modest posture. The other base-fact is that clothing can be far more inflammatory than nudity—a clothed body more lascivious than a naked body. "Clothes have made modesty, not modesty clothes." Ellis has made this as plain as it can be.

At the same time, I have long had the impression that one consideration which somewhat opposes this proposition in its bare form has been ignored (or I think so from memory) by Ellis, Hall, etc. Namely, that in some lands at least (notably the Congo—see Cureau's important "Savage Man in Central Africa," recently translated) caresses of all kinds are so frank and so universally common and so much a matter-of-course that bodies of the opposite sex have neither the erethistic strength nor the insistence as stimuli that they have for persons where some degree of restraint is fairly common. Consistent satiety would provide no continuing motive toward the development of either modesty or clothing. And coldness of the climate by itself is reason *enough* for clothing away from the equator; and the heat of the equator reason enough for its absence there. Second Avenue, New York, early in August, 1917, exhibited on its fire-escapes along the elevated railroad as good an illustration as one need have that modesty in the conventional "proper" sense is easily forgot even by people of the highest respectability whenever life and death or even extreme discomfort are involved in being "modest." Like some other things "modesty" either is sometimes superficial or an obsession.

F. Boyle (see reference in the list below) is typical of the few who like to expatiate on the harmfulness of clothes as covering of the body.

The Art of Scientific Appareling. If the corollaries of the foregoing essay into the psychology of clothes and their wearing be not too indefinite for general acceptance (and perhaps they are not), it is clear that there can be no "laws" social and much less official for scientifically clothing the population. In the centuries past, all such attempts (mostly sumptuary) to legislate have been abandoned forthwith, at first *de facto* but soon *de jure,* as unnatural interference with personalities, whether costermongers or earls. The Quakers have done best in this direction, but only because they have insisted on a relative ***negation*** of the personal "fit"-ness, adaptation, of their raiment.

It is, then, to the ***personal*** "laws" or sanctions of scientific appareling that physiopsychology must apply itself. Clearly enough, these sanctions may be as scientific, as detailed, as elaborate, almost as the relations, physical and mental, of the human and his environment.

To be well-clothed, in the sense of this monograph is to have good taste in many things, one of the surest general indices of substantial intelligence; and is to have a good realization not only of the pragmatic Me, (the only kind with two legs to stand on) but of this Me's intricate relations psychical and material with its effective and ever-flowing and ever-changing environment, as intricate qualitatively even as itself. The female (horrid but necessary word!) with her superior intuition will always remain the passed-mistress of this personal art, and science can do much, but always only in an individual case, to suggest the basal sanctions for the guidance of her habitual intelligence.

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Harvard University has more than a hundred volumes on clothes and costume, mostly historical, and classed as works on the fine arts. From these physiology and psychology are practically lacking.

Modern books and articles on hygiene contain some physiological material, but not much.

Altogether, previous to the present discussion, so far as known to the writer only the four pages by Lotze and the questionary by G. Stanley Hall, both listed above, contain any physiological psychology of clothing worth the "looking up." But the subject is wide-open for discussion.

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Some Imaginal Factors Influencing Verbal Expression

A Preliminary Study

By

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This work was done under the direction of Professor John F. Shepard, and was made possible by the hearty co-operation of those who acted as subjects.

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CHAPTER I

The Problem and the Method of Attack

This study was undertaken to see if any definite and valuable relations could be established between an individual's type of mental imagery and his ability to express himself in oral or written language.

Classroom experience shows a great degree of variation in the power of quick, effective, and pleasurable expression in words on the part of students who are apparently equally intelligent and similarly trained. Some have a facility in the use of words which seems to be a dangerous thing, a temptation to superficialty and confusion. Others "have the idea but can't express it," or not immediately. The stock reply of the teacher, "You mean that you haven't any idea to express, or that it is too vague for expression," though often, no doubt, an accurate diagnosis, does not seem to apply in all cases. Another explanation of the student's inability to express himself, the effect of which is to make all clear thinking verbal, is implied in such statements in the rhetorics as the following by Arlo Bates:[1] "Every student should learn . . . that it (literary form) is an absolute essential of all clear thinking." A number of teachers, asked what part of the process of thinking they conceived of as taking place in words, answered, in the words of one of them, "Thinking and wording are one and the same process." That literary form is essential to all clear understanding on the part of the listener may be granted; whether it is essential to clear thinking is certainly open to question. Intelligent and observant scholars seem to have had experiences similar to those of the inarticulate student. For example, Jespersen[2] says: "If you have to speak on a difficult or unfamiliar subject on which you would not like to say anything but what was to the point and strictly justifiable,

[1] Bates, Arlo, Introduction to Pearson's Freshman Composition.

[2] Jespersen, Progress in Language, pp. 23-24.

you will sometimes find that the thoughts themselves claim so much mental energy that there is none left for speaking with elegance, or even with complete regard for grammar; to your own vexation you will have a feeling that your phrases are confused and your language incorrect." Huxley speaks still more explicitly: "When a whole mass of different structures runs into one harmony as the expression of a central law, that law does not come first in the form of words."

In the discussion that follows, the emphasis, instead of being thrown on the fundamental similarity of minds that makes communication possible, is purposely thrown on the dissimilarities (of less importance, perhaps, but too little recognized in English teaching as elsewhere) that make communication difficult. Verbal imagery is not depreciated; nor the importance of language, of communication, to all higher forms of thought; but attention is called to what is not verbal in thought, to relations existing between types of mental imagery, including verbal, and the process of expression. It is hoped that the results of such study will throw light on the principles and function of rhetoric, perhaps on the handling of different types of students in composition.

The motivation that makes for artistic expression, in literature as in any other art, is bound up, to a very large extent at least, with the instinctive and emotional, the sympathetic, side of the individual.[3] But is there nothing in the mental constitution of the literary artist that inclines him to words as a means of expression, as a musician is inclined to musical sounds, nothing innate to account for the differences in individual writers? Lounsbury[4] makes his "effectiveness" and "beauty" of expression dependent upon the "existence in the individual of an innate ability." Newman, in his essay on *Literature,* says: "I do not claim for him (the great author), as such, any great depth of thought, or breadth of view, or philosophy, or sagacity, or knowledge of human life, though these additional gifts he may have, and the

[3] See Chap. V, pp. 107-122.

[4] Lounsbury, T. R., Compulsory Composition in Colleges. Harper's Magazine, Nov. 1911.

more he has of them the greater he is; but I ascribe to him, as his characteristic gift, in a large sense the faculty of Expression."

After some investigation of the ways in which students learned to spell, it occurred to me that one of these innate factors might well be the type of mental imagery habitually employed. The first step in the procedure, obviously, was to see if sufficiently marked differences of type could be determined to make any correlation with verbal expression feasible. Miss Fernald's conclusions in her *Diagnosis of Mental Imagery*[5] indicate that such differences of type do exist. She finds marked differences in the character of the imagery used, though they cannot be formulated as simply a matter of better or worse imagery of a certain sort, since the characters appearing are to some extent independent variables. Obvious changes, moreover, occur in the imagery of a given subject with changes in the character of the tests. An adequate statement of an individual's imagery type, therefore, would involve an account not only of the specific characters of the kinds of imagery used, but of the kinds of imagery used in various representative situations, with an estimate of their relative importance. She does, however, classify her subjects into two groups, the first consisting of the more versatile, who seem to use visual-concrete and auditory-vocal-motor forms with perfect ease, and the second of those who have certain especially favored kinds of imagery which they use with considerable constancy.

The motivation toward use of words which comes from a particular social environment, the differences in habits of thought dependent upon kind of work done, or on tastes and purposes, could only be taken into account in a general way—that among the subjects there should be those who are preoccupied with verbal expression, and those who are not so preoccupied; that as many tastes and temperaments as possible be represented. It was hoped in this way to avoid errors arising out of the use of subjects of such similar capacities and training that their results could be attributed to factors other than those under investiga-

[5] Fernald, M. R., Psych. Rev., Mon. Suppl. 14.

tion. If certain relationships between imaginal factors and characteristics of verbal expression remain constant through great temperamental and environmental diversities, then the temperamental and environmental factors would seem to be shown to be separable and independent.

The subjects for these experiments were, accordingly, chosen from men and women interested in rhetoric and in science, because it was thought that they would represent varied types of mind, one group especially interested in expression in language, the other dealing primarily with non-verbal material. The first group consisted of four graduate women, one senior woman, and three instructors, men, from the rhetoric department; the second group included two graduates, a man and a woman, and an instructor, a man, from the psychology department, a woman from the zoölogy department, and a woman from the chemistry department. The average age of the subjects was 27.7 years, the ages ranging from 23 to 33 years. One of the rhetoric instructors, By, had been a newspaper reporter, another, Ev, had been for some years a cartoonist. H, E, By, and Ty are writers of verse. T is a zoölogist doing some scientific writing. By and Ty are distinctly musical, Y, T, and B distinctly non-musical. A acted as a subject for Miss Fernald. All were students or instructors at the University of Michigan during the years 1914-15 and 1915-16.

It was decided to use for this preliminary testing the experiments which Miss Fernald had tried and found most successful, with some modifications due to the difference in aim. More emphasis has been put on introspection, and various changes introduced as the experiments proceeded.

The reliance upon introspection, especially where some of the subjects used are not trained to it, may seem to some unjustifiable. But it seems to the writer more and more evident that if we are to discover anything more about the human mind than about the animal this method is necessary; that it would be foolish to throw away the opportunity afforded to us by human speech, that being quite as much a form of behavior as anything else, and, unless the subject is quizzed and led on by suggestion, just as truly a form of reaction to stimulus. The subject's greatest difficulty in introspection is to keep the form of the idea as it occurred during the period he is examining, separate from the development which takes place afterward. Immediate introspection, over a very brief and clearly defined period, decreases this difficulty.[6] What is it that goes on in the mind between the stimulation of the idea and its expression to an auditor in words? is the question to be answered. For the purpose of this work it is just the course of development of an idea, and the forms that it is capable of taking, that are of interest; the introspection, therefore, in all the later experiments is taken to the end of the expression process, with as careful discrimination of the periods in the development and of the chronological order of it as the subject can accomplish. The conditions, though as far as possible under experimental control, were made as little mechanical, as much like ordinary human intercourse, as possible. This seemed especially necessary in the last group of experiments, where otherwise the conditions of natural speech would not exist.

The experiments fall into four principal groups. The first, or preliminary group, is primarily for the purpose of mental diagnosis, and, as has been said, repeats a number of the experiments described by Miss Fernald. All these experiments were accompanied by introspections, which not only supplemented the objective results but furnished practice to those subjects who were unaccustomed to the task.

Preliminary Group

I. The first experiment consisted of the reading of descriptive passages,[7] four read in as normal a way as possible by the subject to himself, two read aloud by the subject, and two read by the experimenter to the subject. The number of passages used and the method were varied more or less; several of the tests were followed by reproductions and all by oral or written introspections. This experiment seemed well adapted to bring out

[6] Ach, Willenstätigkeit und Denken. Kapitel I: Methodik. Die systematische experimentelle Selbstbeobachtung.

[7] For passages used see Appendix.

such concrete imagery as might be suggested to the subject by words.

II. The second was given primarily to bring out visual-verbal factors, and consisted of spelling backwards, and pronouncing from words spelled backwards.

III. This consisted of a series of memory tests, based on arrangements of Roman and Arabic numerals, letters, and other symbols, for example—

B	4	t
=	m	XI
iii	\	l

exposed for ten seconds, and designed to show whether visual images were employed in learning.

IV. Experiment IV was a list of words alike in sound but not in appearance, designed to show whether or not the subject was able to use visual-verbal imagery in learning.

V. Experiment V consisted of making lists of rhyming words, to bring out auditory-vocal-motor imagery, and lists of words with a common ending, like *-one,* to bring out the visual factor that seemed to be naturally involved.

VI. The memorizing of words similar in appearance but not in sound, was intended, like the first part of V, to bring out the auditory-vocal-motor complex.

VII. Experiment VII consisted in reports on the content of pictures and in the analysis of the imagery involved in learning and recalling this content.

When it was felt that a good working idea of the imaginal types of the subjects had been gained, a test in free word association was added, to see (1) if any influence upon imagery of the kind of word given could be detected, (2) what relation the times bore to this and to the general type of the subject, and, more especially through introspection, (3) what sort of mental processes went on during these periods of concentrated attention—for instance, whether concrete imagery having to do with the reaction word ever preceded that word in consciousness. This test consisted of one hundred and thirteen words, chosen largely from what might be called a literary vocabulary, though including a group of simple words from everyday speech, a small group of rare words, and a few distinctly scientific terms. These words were considered to belong roughly to five classes:[8] *objective* words, nouns and verbs, referring directly to material objects or physical actions (carrot, paddle); (2) *sensuous* words, mostly adjectives, that were felt to be especially likely to stimulate simple sense imagery (scarlet, hum); (3) words, mostly adjectives, that denoted characteristics or *attributes* of a less sensuous, or more complex nature (majestic, humble, severe); (4) words, mostly nouns, which on account of their literary history or the circumstances of their daily use are capable, as Pater[9] says, "of stirring a long 'brain-wave'" of associations behind them, that is, words of great *connotative* power (myriad, turf, treasure); and (5) words of a highly *abstract* sort, removed as far as possible from sensational stimulation (also, function). Some words (prose, omnibuses, broadens) used in former experiments were included; and a good many were chosen because of a likelihood that they would evoke others of the same quotation or stock phrase (braes, tide). A Hipp chronoscope and a modified Wirth apparatus were used in this experiment, and the times were carefully kept.

The experiments of Chapter V are an attempt to examine mental processes from the arousal of an idea to its expression in verbal form, either spoken or written. These experiments, that is, have to do directly with the problem: to discover whether any valuable correlations appear between the results of such experiments and the previously determined imaginal types of the subjects.

The experiments of group III are based on picture postals shown by means of a simple mechanical device, in an attempt to produce fairly natural verbal reactions. In series 1, eight cards were shown and the following direction given: Immediately after the word 'ready' is spoken a picture postal will appear; you

[8] It is unfortunate that some of the terms used in classification, as *objective*, *attributive*, *connotative*, *abstract*, are from a logical or philosophical vocabulary. They are used by the writer in default of better, to express various degrees of a possible power to evoke a sense stimulation or image.

[9] Pater, Walter, Style.

are to respond with the first thing that comes into your head to say about it. When the response came its time was noted by means of a stop watch, the card covered, and an introspection asked for. Series 2 consisted of ten cards in groups of five each, chosen so that the cards of the two series were as nearly similar as possible in interest and in type and complexity of subject matter. The direction for the first five asked for a complete statement, oral, embodying the impression or opinion of the subject. This was followed immediately by a timed introspection. For the second five the subject was directed to turn in his chair as soon as any statement came to mind and write it, following immediately with an introspection. 3 is a set of four cards for each of which a different direction is given, the intention being to get a written description under something like the conditions of theme writing. The time of writing is taken with a stop watch. In 4 the cards are described orally and a short-hand account and the times taken.

The last group, IV, was planned to provide a more real-seeming subject matter, and used objects instead of cards. The objects were exposed by turning on a light over a table in the next room, the room in which the subject sat being in darkness except for a desk light. The subject was asked to react with a complete statement to some of the objects, and to write descriptions of others. Some of the objects would be more likely to produce simple sensations, and others a process of identification, of a less automatic sort than appeared in the preceding group. It was felt also that certain of the subjects would be more interested, and thus more fairly tested, by the use of such material.

Literature

So far as I know, nothing has been done upon this particular problem. A great deal of work has, however, been carried on along two closely associated lines: in the study of imagery types and in the study of thought processes. Much has been done upon types of mental imagery, but rather on the forms in which material is learned and retained than upon the expressive side of the process. I am indebted to all earlier workers in this field, and especially to J. R. Angell and M. R. Fernald, whose experiments and conclusions in the field of mental diagnosis I have used freely. The work most nearly approaching this in aim and in method, is that on thought processes done at Würzburg by Marbe, Ach, Watt, and Messer; Pillsbury's consideration of the mental antecedents of speech and Crane's study of association reaction, at the University of Michigan.

CHAPTER II

Mental Diagnosis

The preliminary experiments.

I. Reading of descriptive passages.[10] Subjects differ greatly in the amount, kind, and clearness, etc., of the imagery called up by the descriptive passages which they read or had read to them.

The following reports of visual-concrete imagery illustrate the differences very well. The series from (1) particularly, gives the typical differences of the subjects in the amount of detail and in clearness and completeness of the picture.

Ev. (1. Jefferies. Description of street corner.) Accepted the passage with perfect confidence that I could put it into images, that it was well done and suggestive. Recognized as color description rather than saw colors.

R. (1) More schematic than anything else. Saw vehicles, pale yellow straw.

B. (1) Got triangle and succeeded in rounding off apex. Dim visual image associated with Detroit. Dark mass of forms, indistinct. The carts were very diminutive and wouldn't fit in.

H. (1) Saw carts and streets and movement. Saw high fat things for omnibuses. For "high white wool packs" saw brown sacking with bits of white sticking out.[11]

Y. (1) Scene was quite maplike in definiteness, but small as if viewed from a window above the street. (Speaking of color) Saw especially the red and green, and the shine on the varnish.

T. (1) Saw an imaginary scene which kept overshadowing the described one all the time and becoming more prominent.

[10] See Appendix.

[11] It is perhaps significant that to Ev with his method, the passage appeared "well done and suggestive," to H who had a great deal of confused visual imagery, not to speak of auditory, etc., it appeared "overloaded," "forced."

...Saw Ogden and the station there after a bit, and the carts, etc., filtered away. It was difficult to get details into this setting. There was also a picture of Miss P. feeding the doves in front of St. Marks. Description of vehicles was too mixed... had to read sentence over. Seeing the mountains at Ogden went easier than trying to get traffic....The horses that were champing their bits were nice black sleek horses in coach harness, guards on bit—one, double below with basket work, very ornamental. Lots of foam on horses' mouths. (No conscious effort to visualize.)

S. (3. Scene from Esmond.)[12] Saw white round arm, large, quite out of proportion to figure, persisted as image by itself.

B. (3) Got Beatrix coming down stairs, train appeared in three ways. Saw red stockings and white shoes, separate from Beatrix and from one another.

Ev. (3) Visualized more or less because questioned on first one. Saw only very fleetingly. I can draw from these descriptions in novels—can "see the edges."

H. (3) Saw Beatrix moving in full, shining clothes, with lighted candle. Scarlet stockings show. Saw her advance to Esmond and draw back. Swept curtsy almost to the ground, looking up with eyes and teeth shining. Staircase wide and shining out of dark. Saw turn of landing.

Ev. (4. Stanza from poem.)[13] Reported no visual imagery.

R. (4) Reported no visual imagery.

By. (4) Thought very dimly of woods, camp fires, and wild places.

B. (4) Saw birch log in fire place. Got distinct visual image of self in bed at night, awake and tense. "Young men" just vague forms.

S. (4) Got general picture of woods at night, saw smoke, camp fire, and birch log—part of the time the log was in a fire place, though. (The visual was not the important imagery in this experience.)

[12] See Appendix.

[13] See Appendix.

H. (4) Got picture of recruits going down to St. Pancras station at night.

Y. (4) Subject quite naturally described the picture she had seen. Says that in general she remembers from poetry a picture, not the rhythm or words. Gets this picture "independent" of words—probably in sense of separate form—"as vivid as actual thing seen." The fact that subject very evidently did not get rhythm bears out her judgment.

Visual imagery varies in amount, mobility, definiteness, fitting-together-ness, and in the character of its color; and these are apparently independent variables. H, for instance, has a great deal of mobile, fairly definite, bright-colored imagery, making a related whole; B has a little distinct and immobile and a fair amount of indistinct imagery, which when distinct does not form a related whole. Imagery appears also to vary in the accuracy of its reflection of the passage that stimulated it. Sometimes the associations called up by a single word or phrase control all the rest (T and H). It is something of a question whether a distinct picture called up in mind by the words read, as in the case of Y, or the clear visual imagery called up by association, as in the cases of T and H, marks a higher degree of visualizing power. It seems probable that the latter is at least a clear indication of the effective habitual use of visual imagery, of a high degree, that is, of persistence of visual memory.

The types of imagery reported by individuals seem to differ as much as the type may vary within its self. Except in the stanza (4) with its definite appeal to olfactory imagery,

"Who hath smelt wood smoke at twilight,"

no trace of such imagery is found, and there only in a few individuals. In at least two other passages an opportunity for such imagery was offered, in (5),[14] read by part of the subjects, where the line occurs

"Like pious incense from a censer old";

and in the description of sea and earth, (6).[15]

[14] See Appendix.

[15] See Appendix.

B. (4) Had consciousness of smelling, kinaesthetic sensation.

Y. (4) I got name, woodsmoke, and saw it, got tang of it but not first hand smell—the fact, rather, of what the author wanted me to sense.

R. (4) Image of smell.

E. (4) Smell damp wood smell.

Ty. (4) Conscious of something acrid, pungent, delightfully woodsy, in the beginning. Choked by woodsmoke rather than smelled it.

Auditory imagery, apart from the auditory-vocal-motor complex, was reported fairly freely and with certainty by two subjects only, R and E, but occasionally by nearly all.

E. (7)[16] Heard the whirr of the waltz clock before it started even; (4) heard the wind. (Likely to hear everything she reads in a low-pitched woman's voice, not at all like her own.)

R. (1) Heard the "jingle, jingle, jingle", also heard a Christmas carol, and the horses' hoofs on smooth pavement; foreground was sound, background sight; (4) auditory memory of the rhymes; (6. Asked to reproduce what he got from it.) "The wheat which *crackles* in his hand," "sea, bright blue and *booming* lazily on the beach."[17]

S. (3) Heard intonation of voice during Frank's speech, almost making sounds to myself.

T. (1) When asked about the effect of the word "jingle" reported: The noise in this passage was not a jingle, it was *clatter*. I heard the horses' feet on pavements.

B. (1) After the thought, I should be getting imagery here, got faint jingle off in corner.

H. (4) Heard the birch log burning; you couldn't help it.

The near auditory imagery reported is interesting. It seems to be a mixture of sensations, kinaesthetic and organic.

S. (9)[18] No auditory images except that the word 'pealing' gave a slight feeling of tenseness in my head, as though I were

[16] See Appendix.

[17] It is, of course, quite possible that neither *crackles* nor *booming* represents an actual sound heard, but they are at least typical of this auditory subject and quite different from any word used in the passage itself.

[18] See Appendix.

straining to make a shrill sound. (7. read aloud by subject) "Sighs" and "chinks" by their sound suggested auditory images different from the sound of the words. I think the saying of the words acted as a spur.

Y. (3) Didn't hear conversation, but got a *ringing* impression different from what I would have had from pantomine.

H. (3) Got the feeling I would have had if I had heard the speeches, a sort of jolly, genial feeling of Frank, for instance; but can't say I *heard* anything.

Ty. (1) Noticed "color champed, as it were, like bits in the horses' teeth" as a desirably apt expression from literary workman's point of view. Recalled the phrase, no auditory imagery.

Sc. (1) For "champed," etc., thought of horse champing at a bit; thought of what it meant. ("Jingle, jingle, jingle, A... jingle," saw as it looked on page.)

Passage 8, the moving of crossed knife edges,[19] which was expected to bring out auditory imagery, was much more fruitful of kinaesthetic and organic, even of tactual, sensations.

Ev. I squirmed. No sound. Not a matter of sound, a matter of edges.

B. I felt my teeth on edge. Did not hear it.

By and E got only visual imagery for some moments.

S. Physical reaction to grating, did not hear them grate.

Sc. Sharp feeling, sort of circularly located in upper body. (Much delayed.)

Rg. Got feeling of sharpness.

H. Very uncomfortable. Persistence of shuddering and teeth on edge sensations for some time.

R. Heard a swish of knives. Later, set teeth on edge faintly. (5) Vivid sensations of shivering.

Ty. The blades scraped *hideously*. (Delayed.)

In general those who got a visual image and were preoccupied with it, had a complex visual-motor process on their hands,[20]

[19] See Appendix.

[20] E. Just saw the knives, they sort of glistened, the blades together. They

and had no organic sensations unless at the close, much delayed. This reaction probably shows a visual preoccupation, resulting in part, perhaps, from James' phrasing, and in part from a less strong tendency toward organic reaction. (By, E, Ty, Sc, and S.)

Motor sensations were apparently an habitual form of reaction to two subjects, R and B, and much of the effect of rhythm and cadence reported was declared to be motor, By, a good deal of a musician, going so far as to say that his memory of music was altogether of that sort, though he was keen at recognizing or identifying musical sound. Sc gets a great deal of motor combined with visual in dramatizing,[21] and uses gestures freely in giving introspections.

R. (4) "Don't remember poetry because I read rhythm instead of the words, accent for structure rather than content." (Of the smoke) "Rather felt it going up, as if I were the smoke." (6) "*Was* the man." (Subject in his reproduction added a good deal, both in meaning and in content.) (8) Motor and tactual. R "immediately got in his place (the holder of the knives) and felt prick of knife." (5) Motor and tactual. Was moving rosary beads.

Rg. (4) All I'm conscious of is the rhythm. I'm conscious of it as a rhythmic unit.

E. (4) Knew it was Kipling though hadn't read it. "Nobody else swings a line over like that third one."

were moving supernaturally. Subject drew them as she said they looked, flats of blades together.

S. Saw two silver table knives, then realized that they were steel and rather deliberately changed image to "kitchen" knives.

Ty. Carried this adjustment through three stages: Two blades (picnic table knives) laid flat, sharp edges toward each other; blades suddenly turned so that sharp edges are in contact, blades being held stiffly upright, crossed in middle; blades begin to draw back and forth, turn thinner and sharper.

Rg. Saw shiny edges plainly, and black handles. Got them parallel; scissor wise; then crossed keen edges at right angles.

[21] Sc. (3) Had all in position, but Beatrix was only one really imaged. Resented phrase "almost to the ground" as too strong. "I made her do it in a way of my own." (Motor, or possibly visual-motor.)

H. (4) Calls up a similar rhythm—Robert's *Vagrant's Epitaph.*

Ev. (4) Got a sort of tripping motion.

Some of the sensations reported seem to be more properly described as kinaesthetic sensations of weight, strain, pressure, etc.

B. (4) Kinaesthetic for "feet are turning." (2) Kinaesthetic aroused with "take the field," and "transport his army," a certain feeling of strain as if I were picking them up and transporting them.

Ty. (3) I stood squeezed up against the wall.

Feelings like the following are hard to classify, but seem to those experiencing them to have an imaginal or sensational content.

E. (1) Felt as I feel sometimes in a crowd. (4) Felt Esmond (his presence). (7) Felt Markheim's strained mood.

S. (4) I was principally conscious of a thrill or a lure, suggesting at once Walt Whitman, the Open Road feeling. I think the words "Follow" and "turning" gave the lure feeling, although they were not in mind at the time. (Of a passage from James): Recognized passage was from James and had "last year Vassar" feeling, to some extent a feeling of locality. I was somewhere off to the left. (Very typical.)

B. (1) Conscious of effort. (2a) The word "king" gave a feeling of nobility.

Ty. (8) Felt as if I were in danger of getting between them (the knife blades). (3) Impression of elderly stout gentleman —of dignity and bulkiness.

Rg. (4) Underlying association of White Mts. got by means of fireplace in our cottage.

Very often the subject was unable to analyze his mental content but reported something very definitely there. The word unanalyzable, used to describe mental content, indicates this inability on the part of the subject to analyze, to carry introspection further.

Ty. (4) Disappointment—when found that they were to *leave* for camps.

Sc. (3) Resented a phrase employed. (Because it did not fit his own procedure.)

H. (4) Disappointed in the end.

Rg. (4) Conscious of emotional atmosphere.

Sc. (4) Suggested Longfellow. Afterwards said it "savoured of *Hiawatha.*"

E. Very sensitive to mood in all cases.

S. (4) Things mentioned bring a feeling without the interposition of any image.

Y. (4) I knew the stanza took form of questions at the beginning and a command at the end.

Ev. (1) Thought of mixed figure in wheel and pool without having images of either—or of anything else. I think I knew what the words meant—didn't stop over to get image. (Explanation of statement that he "had an idea what the streets were like.") Often recognize that thing is capable of being interpreted without interpreting it. (4) Got significance of words, no visual imagery.

B. (3) Indistinct feeling of female spectator at one side.

Ty. (4) Felt it a desirably apt expression from literary workman's point of view.

Sc. (4) Just got idea of last two lines, no imagery.

By. (2) Got a very definite impression of McClellan's character; got significance rather than events.

Rg. (2) Called up in mind a series of articles on Confederate and other generals running in *Atlantic* last year. Conscious of situation at time of reading. No analyzable imagery, except later of a printed page, but think that came during attempt to analyze.

Verbal imagery in this test was not a primary consideration, and, as usual, where auditory-vocal-motor occurred it was difficult to discriminate between centrally aroused sensations and peripherally aroused or articulatory.[22] Reading a passage silently gave much better results for some than for others, especially

[22] So far as any distinction can be made the phrase auditory-vocal-motor is used in this paper to indicate the centrally aroused, and articulatory to indicate the peripherally aroused sensations.

good for Ev, Ty, and Y. H and B were particularly successful in recalling the stanza (4) as compared with the prose (2). Y recalled the words of the stanza fairly well, but with almost no sense of their rhythm.

Number of details recalled from (2).

1st group: Y. 27 (familiar with territory), Ev. 19, Ty. 17.

2nd group: Sc. 14, E. 14, Rg. 14, S. 14, H. 13.

3rd group: By. 12, B. 11, T. 9, R. 9, By and R "not interested in material."

Words recalled from (4).

1st group: Ty. 31, Sc. 31, H. 31.[23]

2nd group: B. 26, Y. 21 (remembers poetry as picture), Rg. 21 ("All I'm conscious of is rhythm.").

3rd group: E. 17, Ev. 15, R. 7; no visual imagery reported.

Several subjects reported visual-verbal in recall, especially in the case of proper names or other noticeably printed words. Sc (2) had visual-verbal imagery of the opening phrase, 'Throughout the winter of 1861-62,' and of 'maneuver.' He remembers vaguely how the names of the four rivers looked.

The criticism of I that grows most clearly out of the introspections is that the reading is either undirected—purposeless—or motivated unnaturally. The results are, therefore, as typical reading results, not very trustworthy. The possibility of certain imagery's appearing and the tendency of other imagery not to appear in connection with words are, however, satisfactorily shown. The least flexible types are E, Y, and T, visual-concrete, and Rg visual and motor; the most flexible, Sc, Ty, and By, using visual-concrete and vocal-motor principally.

II[24]. Spelling backwards, and pronouncing from words spelled backwards, given to bring out visualizing power.

Spelling backwards, orally, grouped the subjects roughly into two classes, a class that used visual imagery a good deal, and a

[23] H said "dear, dear, dear," while writing rapidly. Did not seem to be in the least an inhibition. Points probably to verbal imagery unaccompanied by articulation.

[24] See Appendix.

class that used it little if at all. Of the visuals Ty, Sc, By, and T use the method effectively, making high records in time and correctness; S uses a mixed visualizing and pronouncing method —she wanted a blank space before her to visualize upon—and has a fairly good record; Y and E make slow times, ranking 9 and 11 in the list, and are poor spellers here as elsewhere. Y "sees the general shape of the word before beginning to spell it, but the distinct image of the letters only after spelling them out." E wrote the words on a blackboard a syllable at a time and became very much confused. Of the articulatory or motor type, R has an average time record and for writing is perfectly correct; H, who has a time record corresponding to that of the visuals, says she has "a feeling of dashing at the words to set them running backwards on their own wheels, if you stop, the motion is gone and everything is lost" (a process apparently similar to Sc's). Ev describes his method as phonetic and is constantly troubled by a sense that the process is wrong. B spells the word forward several times, and has, probably consequently, a very slow time, although the fact that she considers herself a poor speller, and is, undoubtedly contributes. As to visual imagery she reports, "when I look at a visual image of a word it isn't there." Spelling backwards in writing adds very little to the oral results. The objective results as to time are almost exactly similar. T is bothered by the sight of what she has written—"they got sort of upside down in my mind and I can't read backwards from them"—and loses four places. Rg falls from 16.5″ to 33″; she reports it "much harder" and covers written portion with her hand. R, who writes from right to left, is aided, and steps up three places. The per cent of words spelled correctly rises considerably, 10%; the great improvement is with the motors, and the great fall (30% B) is also motor.

Pronouncing from words spelled backwards gave the same rough grouping as the preceding test. E varied very much, her visual method giving quick times with short words, and very long times with long ones; with two letters per second her time improved markedly, apparently through the appearance of auditory

Table a.
Spelling backward. Time records for right spellings.

Subject	Oral: Av. time in seconds	Oral: Per cent right	Written: Per cent right	Type
Sc	7.6	55	100	Visual and vocal-motor.
Ty	9.2	80	88	Visual.
By	13.5	80	90	Visual.
H	15.8	50	100	Vocal-motor.
S	16.4	60	50	Mixed, visual and vocal-motor.
Rg	16.5	40	80	Mixed, visual and vocal-motor.
T	16.7	80	70	Visual.
R	20.2	70	100	Vocal-motor.
Ev	21	60	50	Vocal-motor.
Y	26	80	60	Mixed—emphasis visual. Poor speller.
B	27.2	80	50	Vocal-motor. Poor speller.
E	59.5	40	60	Visual, some vocal-motor. Poor speller.
Average	15.8 (without E) 20.8 (with E)	64.5	74.8	

aid. Y reports: "When I heard the letters I saw them upside down, tried to hold them all in mind and then turn the paper ground (on which they were written) around so that the word would be in normal position"; with one letter per second this process, though complicated, did not seem very difficult, with two letters per second, "guessed more." Of *rudimentary* Y reports: "Tried to see on blackboard right to left. Did not show till Miss S—— had finished spelling it. When she said d-u-r *rud* appeared on the board, and quite a way from it, giving the idea that the word was a long one, then came *ary*. *Rudimentary* then popped in. Even when middle letters are blurred you know whether they fit or not."[25] By reports that some peculiar combination of consonants and vowels identified nearly every word; when letters came two per second "there was usually nothing conscious but a guess." S reports a still more mixed method,—"In some cases I had to respell a syllable backwards. The *sound* ran in my head so that I could." Sc reports that he sees the word, knows how

[25] Good spellers appear to have paid more attention to words as groups of letters. Compare By and Y.

big it is, how many letters there are in it, and everything like that, "builds it up objectively, out in front," but he can not tell whether it is in print or writing.

B, of the vocal-motor group, reports that after trying several methods unsuccessfully she "reversed in some way not visual." Ev says there was a good deal of guessing in his results; "When the word ends I can think back over the last three or four letters and turn them around." R learned to spell the word backwards, usually from one spelling, lip-motor, and then was "disinclined to work out the word as I know I have it there for the working"; his times in consequence are long. In general, the advantage in objective results goes to the good guessers. Sc and Ty both reported that they often knew the word before I finished; Sc (*Belgium*) "wanted to cut in at *l*."

Table b.

Pronouncing from words spelled backwards. Time record of right pronunciations.

Subjects	Av. time in secs. 1 letter per sec.	Av. time in secs. 2 letters per sec.	Type
Ty	9	8.5	Mixed, auditory-vocal-motor and visual. Guesses.
Sc	9.5	10.4	Mixed, auditory-vocal-motor and visual. Guesses.
By	10.9	16.8	Visual. Guesses.
S	16.8	10.7	Mixed, auditory-vocal-motor and some visual. Guesses.
T	17.7	20.9	Visual.
B	22.9	24	Vocal-motor.
Y	25.5	15.3	Visual. Guesses (2 per second).
Rg	26	38	Visual (many spellings).
H	34.5	53	Vocal-motor. Wrong guesses.
Ev	36.7	29	Vocal-motor. First step slow, then guesses.
E	39.3	25.5	Visual. Improvement in 2 per second due to auditory aids.
R	80.5	13.3	Vocal-motor, with articulation. Passivity after first step.

Individual differences, of temperament largely, enter into the results in the speeding up process of spelling two letters per second; some for instance, "like to take a chance," others find it hard to guess.

III.[26] This experiment in the learning of arrangements of

[26] See Appendix.

numbers, letters and so forth, has been much used by investigators to bring out visual factors. So far as easily analyzable processes are concerned, however, the method followed by most of the subjects of this investigation is pronouncing, articulatory; it is usually aided by various associative processes exceedingly difficult to analyze into any definite imaginal form. Our habitual use of an articulatory or pronouncing method for all memorizing of word and letter material seriously affects the value of the test for visual imagery; an individual who uses visual images freely, even visual-verbal when driven to it as in II, might use vocal-motor here from sheer habit. The associative processes, mentioned above, seem in many cases to play the important role in memorizing. The subject is not aware of either visual or vocal-motor elements, cannot tell how he learns, learns it "as a diagram," is "aware of relations." That is, these results bear out those of T. V. Moore,[27] in *The Process of Abstraction,* where he says: "besides the visual image there is something else which is a powerful aid to memory. And this is a more or less complete mental analysis of the figures, an analysis which it is utterly unnecessary for the subject to put in words....And while the two may go hand in hand, they need not; and it is possible to memorize by either method." Again: "It is much easier to memorize by analysis to the exclusion of imagery than vice versa." I do not feel justified, however, in saying that this learning "by association" takes place "to the exclusion of imagery." Motor imagery is extremely obscure and difficult to detect, and imagery may be so reduced, so fragmentary, so complex in its combinations, that the subject is unable to analyze his mental content and becomes confused. The test might prove more valuable in showing those who make ready use of associations and relations than for anything else.

Measured by their success in learning the squares, subjects rank as follows.

[27] Moore, T. V., The Process of Abstraction, pp. 140-141.

Memory—Roman and Arabic numerals, letters, etc.

Subject	6 item tests Av. no. recalls	9 item tests Av. no. recalls	Method of learning
B	6	7	Articulatory, visual associations.
By	6	6.66	Articulatory, probably mixed.
Ty	5.5	7.3	Articulatory, schematic relations.
A	5	5.2	Visual-motor.
Rg	5	4.66	Articulatory, some visual, meaningful combinations.
S	4.5	5	Articulatory, localization (visual-motor) associations.
Sc	4.5	6	Articulatory, visual. Perseveration in recall.
R	4.5	5.33	Articulatory, non-visual. Motor relations.
Ev	4.5	4.66	Articulatory and visual.
T	4.5	5.66	Articulatory, visual-motor lines; visual relations for 9 items.
E	4.5	4.66	Articulatory and visual.
H	3.5	5.25	Articulatory and visual, meaningful combinations.
Y		4.33	Articulatory and visual.

Those who used an articulatory method helped out by visual—a rather clumsy and detailed use of imagery, perhaps —seem rather more likely to come out badly in the objective results than those who used less visual and depended upon 'schemes' and other associative aids. With six items the results seem to show three distinct levels of ability to learn this material. With nine items this grouping, after the first two names, seems to disappear. Ty and H show the greatest improvement, T improves in the second test, and reports that the improvement is due to use of visual relationships. H shows great variation, from a perfect test with nine items, to three accurately placed, and four correct but wrongly placed in a similar set. She remarked in the second instance, "Why, there's nothing there to say!" From which it may be inferred that her success in the first instance was due to her hitting upon a meaningful combination to repeat. Those who showed themselves capable of using visual imagery here are those who have used it in other tests, except that By does not *report* visual imagery here and does in all the preceding tests.

It seems probable from the introspections of III that the articulatory or pronouncing method of learning may give rise in the recall—in reproducing the diagram—to vocal-motor imagery.

IV.[28] Learning lists of words that sound alike but are spelled differently would, if anything, it seems, bring out any disposition on the part of the subject to learn this kind of material visually. From the results, however, it would appear that there is very little tendency to use a visual-verbal method in learning words; that, on the contrary, the habit of learning by a vocal-motor method is too strong to be overcome by the exigencies of the situation. The subjects all depended primarily on that method, though using visual images, sense combinations and other associations as aids. The results show marked differences in ability to get such material, however. Of the three who succeeded fairly well, B reports, "used visual as a check"; S, "made sense. In b. got lines 1 and 2 by association, just looked at 3 (all were right), figured what possibilities were left. Had fairly definite image of *heir*. In c. got help from visual"; By reports for c., "got first three by sense clause, corrected list by visual, the last was deduced." It would seem evident that all three used visual imagery to some extent, being much more conscious of a visual preoccupation in recall than in learning; all three used associations, and two "deduced."

Number of words recalled from lists of nine each.

Subjects	B	S	By	E	R	Ev	H	T	Ty	Sc	Rg
Test a.	7	5	7	2	3	1	0	2	3	3	3
Test b.	6	9	5	5	4	4	4	6	6	4	5
Test c.	9	7	9	4	3	4	2	5		9	7
Average	7.3	7	7	3.6	3.3	3	2	4.3	4.5	5.3	5

The middle group, T, Ty, Sc, and Rg all report some visual imagery. Rg improves her method somewhat; for b., "tried to hold together the sequence in sound with the difference in spelling"; for c. "used meanings." Sc reports of a., "had great deal of difficulty organizing"; of b., "Learned by saying columns, tried to get some way to group, sure 1 of column 3 began with *y*, remembered how it looked"; of c., "Got sense out of first column, visual helped, had it cold both ways. Could see 1. Put meanings (see T) into second column as went along. Thought of *sow* as pronounced *sow*. Knew visually that *aye* came last." It

[28] See Appendix.

seemed to the subject that he used both visual and articulatory all the time; his method improved. Ty reports for a: "skipped all about, paid no attention to order, tried to place by sound I guess. Remembered the first, the last, and the first of the second column —salient visual positions"; for b. "learned the sets of three and then looked to see where they came, learned first column, first word of second and third, and last of third." T tried a. by getting variations of order, vocal-motor; b. was learned "by saying the words over and by looking at them—took meanings into consideration, that is, tried to put together spelling and meaning and remember by the meaning the column it went in." During introspection the subject recalled that the first word in the middle column of three was *rays* instead of *raze,* "had a remembrance of the way your *y* looked as it came down there." For c., the subject made sentences and visualized, and didn't really get to the last column. I take it that the suggestion of sentences acted as a deterrent. On the whole, some degree of visual activity seems to be necessary to even a moderate degree of success.

E reports a good deal of visual. For a: "tried saying in order written, tried to get the three different kinds of *sent* by the way they looked." In recall, "I saw *cent* written and *ascent.* Saw the full *s* in *scent* and it suggested *ascent.* For b: "tried to remember the sound, tried to visualize the forms." In recall, "Heard them, in a different voice. Saw a woolly lamb associated with *ewe,* saw a *pear* on a tree in a garden, kept seeing *pair* in other places, hazy." The confusion of imagery, including a good deal of visual-concrete, may account for her comparative lack of success. This subject had trouble in concentrating on the task, not only here but elsewhere. B reports a purely articulatory method. Ev "couldn't do it," "meanings funny, may have inhibited, no visual." H learned "by saying"; she was much confused.

V.[29] The first part of V consisted of making lists of rhyming words, as many as possible to a minute; the test was planned to bring out auditory-vocal-motor factors.

[29] See Appendix.

TABLE A.

Rhyme words.	Ty	Y	S	B	By	R	H	Ev	T	E	A	Sc	Rg	Av.
home		5	6+1w*	4+1w	6	8+1w	7	8+1w	6	6	7	7	5+5w	6.25
speak	13	6	10	6	12	10+1w	9	9	10	5	8	9	9	8.9
case	9	5	9	4	12	8	9	12	6	7	7	10	7	8
hope		6		6	8	7	8	10	6	6	6	10	11	7.6
low	16	12+3w	12	11	11	13	15	14	10	10	10	15	9	12
Av.	12.6	6.8	9.25	6.2	9.8	9.2	9.6	10.6	7.6	6.8	7.4	10.2	8.2	

* w = wrong.
First group: Ev, Sc, Ty.
Second group: H, By, R, S, Rg.
Third group: A, T, E, Y, B.

The first objection to the grouping from the objective results that rises to the investigator's mind concerns E, who is, however, likely to rank lower than might be expected on account of general hesitancy and nervousness, and lack of close attention. The matter is complicated by her being a verse maker and more than ordinarily sensitive and effective in the matter of rhymes. Y, also, though no rhymer, is a teacher of English and might reasonably be expected to stand well in such a test. There is one factor brought out in the introspections of both that may influence their results, by distracting the attention somewhat from the task, and by increasing the time of the individual words.

Y. (Home) "As the words came to me I had a rather vague picture, not so much of the word as of what the word stood for. This was especially true of *Rome,* where I saw only the capital *R,* but had a distinct picture of the map of Italy." (Speak) "With all there was a background, an image made up partly of the way the word looked, partly, and more markedly I think, of occasions for which the word stood. In *meek* I had a general shifting picture of bowed heads. With the last three words came quite distinct pictures of the things for which the words stand, a plump *cheek* against a background of nothing, a generalized picture of a queer looking person, a *freak,* and the head—profile—of a bird, something like an eagle, for *beak.*" (Hope) "All have more or less of a halo."

E. (Home) *Roam*—saw tramp; *dome*—"saw top of cathedral in Florence"; *tome*—"saw great big book with heavy covers, saw gilt on the leather." (Speak) *meek*—"very gentle looking person's mouth." (Hope) *mope*— "saw relaxed figure"; *soap*— "heaps of bars of ivory soap." Subject checked as colorless such words as *go, know, cope.*

B, who from her vocal-motor tendency might be expected not to come at the bottom of the list, reports that many nonsense syllables came up (she was a laboratory psychologist and familiar with them) and inhibited the sense words, and that her process was purely articulatory.

Of the three who stood highest, Ty reports a little visual concrete imagery, but certainly not enough to interfere with the process, as in the cases of Y and E. Ev reports "a purely rhyming process," and Sc much the same thing. Sc used "certain likely consonants with the ending," after the words began to come slowly, and in the case of the last word (low) worked with *ow* for a long time, a visual suggestion from *low.*

Of the second group, By reports that he noticed no auditory or visual images, "words come very quickly and crowd each other out"; H thinks her rhyming is very largely auditory, "heard $\bar{e}(a)k$ much more clearly than $\bar{o}n(e)$ [Letters in parentheses silent], the sound is sharper." H also gets many associations with words: *beak*—"bird, neither word nor concrete visual image, just general idea of bird with emphasis on *beak*": *mace*—feeling of king, also of spice—"impression of shelf where we keep our spices"; Wace—"associations with the beginnings of English literature, with a blue book by Mr. Schofield, lower left hand page, a class in English literature four years ago, and the look of the room and the feeling of teaching that class, all together and very vague." Words "have meaningful air even when nothing definite can be introspected." With R, the visual-concrete imagery accompanying the words died out as the process became more practised, and showed at all times a tendency to come up only when there was a hesitation of some kind: *gnome*—"saw one, a little fellow walking around"; *leek*—"hesitated over spelling and saw onion, long green stalks." His list for *low* was unusual in that it included five words like *yellow.* In discussing these words he let slip the remark that he saw the *ow.* T apparently used visual imagery with auditory-vocal-motor, the slow method of one unused to rhyming. Rg had five wrong in the first set; "ō sound caught me and I couldn't help myself." There was other evidence of auditory imagery: "Heard the words, sort of said them to myself, but with your intonation." For *hope* she got such words as *microscope, antelope, cantalope,* and for *low, window, elbow, meadow,* etc.; "There is a flash almost as if you saw them, all at once, but you *don't* see them." These words certainly come more from visual similarity of form than from rhyme in the strict sense; are dependent, that is, on sight rather than on sound.[30]

The second part of V was designed to bring out visual-verbal, and consisted of finding as many words as possible in a minute that should have the same ending as a given word. The results follow.

TABLE B.

Ending	Ty	Y	S	B	By	R	H	Ev	T	E	A	Sc	Rg	Av.
-one	9	4	3	6	11+1w*	10	5	8	3	3	10	9	10	7.
-ough	8	6	4	3	7	8	7	5	7	3	6	7	4	5.77
-ose		7	5	5+3w	11	8+1w	9	11	7	7	8	8	2	7.3
-are	12+1w	6+3w	8	8	10	9+1w	11	11+1w	12	10			8	9.5
-ine		7+1w		7	15	12	9	16	10	9+1w	12		9	10.6
Av.	9.6	6	5	5.8	11	9.4	8.2	10.2	7.8	6.4	9	8	6.6	

* w = wrong.
First group: By, Ty, Ev, R.
Second group: A, Sc, H, T.
Third group: Rg, Y, E, B, S.

E's introspections show that improvement followed upon the adoption of a visual instead of a rhyming method. T, however, got longer lists with a rhyming method. Of the first group all used a mixed method, auditory-vocal-motor and visual; auditory marked for R, visual used by By and Ev only as test, visual method reported by Ty as most important. A, Sc, H, and T all used a visual method supplemented by articulatory. Of the third group B seems unable to use visual, uses articulatory rather than rhyming, even as a test; E found her ability to visualize interfered with by a rhyming habit; Y, using sound tested by visual—lack here as elsewhere, of vocal-motor—makes

[30] Matthews, Brander, A Study of Versification, p. 49. "Rime in English is an identity of the vowel sound in the last long foot and in all the sounds that follow it."

a slow and faulty record; S uses a rhyming method, interrupted by a slow visual. There is evidence of visual in some of Rg's words—at least of a method not rhyming. For *ough* she "couldn't get away from the sound of ŭff"; and had long a sound for *ave*. In the case of *ose*, she "couldn't seem to focus attention on either sound or form."

The third part of V, in which words are to be given for a particular ending and arranged in groups according to sound, gives results that are extremely difficult to interpret. There seems to be a premium on a mixed method, where both visual and rhyming (auditory-vocal-motor) factors are present. We should expect to find By, Sc, and Ev in the lead, and do; R, H, A, and T following. Ty is unexpectedly in the last group; the trouble is a lack of flexibility somewhere, possibly a visual preoccupation, followed by a rhyming; she wants to rhyme. There seems to be a real difficulty in discrimination here with both Ty and E, both of whom are delicate and effective verse makers, with strong tendencies toward concrete visualizing. Rg also shows lack of flexibility here.

In the whole test, those not concerned in daily practice with words (A, T, B, R, Rg) do not come in the first five; but S, Y, and E who are concerned with words do come in the last five, S comparatively non-imaginal, Y and E very imaginal.

VI.[31] The learning of words pronounced differently but spelled alike would seem to require auditory or vocal-motor imagery or both if any degree of success is to be attained. Associations and generalizations were, however, used successfully, and in the cases of Y and E at least, concrete visual representation of their meanings helped to hold the words in the right order. Y reports, for a perfect score, "When I went over the list I actually saw the things they stood for and I think that helped. Saw a dòve. Saw cliff and water for *dōve*. *Bow* was bow of boat. *Ā*(*ye*) and (*a*)ȳ(*e*) never seem really to look alike [Letters in parentheses silent], the look of the thing they stand for is different, *Ā*(*ye*) is round and full, lighter in color,

[31] Appendix.

(*A*)ȳ(*e*) is sharp, dark, concentrated." E, six out of nine, "I tried to remember by forming a picture." T associated *wĭnd, băss* (Base Lake), *rŏw,* accompanied by some visual-concrete imagery, and recalled *rōw* in consequence. Sc "Tried to remember pronunciation by remembering meaning." Auditory imagery appeared clearly with Y, T, E, and S. Y "remembered there were soft sounds at beginning, and hard and more disagreeable at end, heard *dōve* and *bŏw* plainly." In the first set E had five out of nine correct, and two more vowels correct, said she remembered how they sounded. B was apparently vocal-motor, rather than auditory, and had no visual imagery. She thinks the use of her fingers as she listened gave her motor associations that kept the words in order. In the second test she reports, "For the most part I thought of them (the subjects held an unmarked list of words) before you pronounced them, and remembered in most cases from the fact that you did not give the pronunciation I had in mind." Apparently she remembered, therefore, from her own articulatory imagery, rather than from auditory impressions from my reading.

Subjects	1st test	2nd test	Method of learning
B	6	9	Motor, largely vocal-motor.
Y	5	9	Auditory and visual-concrete principally.
S	6	6	Auditory-vocal-motor.
E	5	6	Auditory? Visual, both concrete and verbal.
Ev	3	5	Says no auditory. Vocal-motor and articulatory?
Sc	6	7	Probably auditory-vocal-motor and meanings.
T	4	7	Auditory-vocal-motor. Some associations and deductions.

Very different methods seem to work successfully. The experiment gives clear introspections of method, rather than trustworthy objective results.

VII.[32] Miss Fernald made use of reports on pictures for testing the presence of concrete visual imagery; she concludes that the absence of such imagery furnished rather satisfactory evidence of some degree of weakness in it. Reports on cards exposed, as Miss Fernald exposed hers, for ten seconds, led me to

[32] Appendix.

think that the long exposure gave time for the development of a naming process that might obscure the visual elements; and that if I wished to discover how much could be retained without such help I should have to make a much shorter exposure. These results are, therefore, based on 2″, 10″ and some 4″ exposures, whose relative value will be discussed at a later point. If the visual types could be determined by proficiency in this experiment the subjects would be rated as follows, visuals of course leading. Subjects were not, however, urged to write exhaustive accounts of detail, as it was feared that they might be led into mechanical and unnatural methods of learning.

Subj.	Absolute No. of Details			% of Details			Method
	2″	4″	10″	2″	4″	10″	
Ty	14.3	(12.5)*	18.3	65	(58)	67	Visual (visual-motor). Some verbal.
Sc	12.6	14	17	61	64.5	61	Visual, and verbal in 10″.
Y	12		14.6	58		61	Visual (and motor).
A	11.5	14.5	10	56		46	Verbal and visual (visual-motor).
By	10.7		17	52		71	Visual. Some verbal.
Rg	10	(12.5)	14	50	(58)	50	Visual. Some verbal, esp. 10″.
H	9.7		12.5	47.5		47	Visual. Verbal in 10″. Motor.
S	9.7		10.3	47		39	Visual-motor. Verbal. Associations.
Ev	8.7		12	42.5		47	Visual. Verbal in 10″. Associations and relations.
R	8.7	12	13.8	42.5	51	58	Schematic (visual). Verbal. Motor.
E	8.7		14.3	42.5		66	Visual.
T	8.6	13.3	11.7	41	51	51	Visual. Motor.
B	7.6		12.7	37		47	Verbal (esp. 10″) Visual-motor. Meanings.

* Figures in parenthesis based on two records only.

When the method is considered, however, it is seen that though the highest places are taken by subjects who use a largely visual method, some of the lowest places, especially for 2″ exposure, are also held by visuals (E, T). On the other hand, it is noteworthy that those who make a marked advance, both absolutely and relatively, with an increased time included these same individuals. These per cent results for 10″ are apparently a pretty good indication of visualizing power, and are borne out very well by the previous tests except that R attained his results by a very mixed method, and that, from the introspections, the visual T would be expected to rank higher.

Now as to the determination of these methods of learning and recalling.

In the examination of visual characters the first thing done was to study the color imagery reported. Subjects varied a good deal in this respect. Some are much preoccupied with color and with light and shade—H, By, Ty, Ev, E. Ty: "A night scene, dark blue sky. Stars, snow on ground and on post. Pleasant contrast in color in that lighted doorway—very green Christmas tree against reddish orange interior. In houses on right pleasant contrast, warm lights, kind of vermilion, in dark blue or green houses." Some remember the colors they see with great accuracy, as T; some see in recall more vivid colors than are in the card, as Sc and B; others fainter as Ev, who after delayed recall reports that when he sees cards again he finds colors brighter than he remembered them. Often colors are reported that are not there at all; H particularly, recalling a black and white photograph of a garden, saw "Hollyhocks of glowing colors, reds and pinks, bees humming in them, under hot sun," and R, also recalling a black and white print, reports "Sky a sort of yellowish blue." Rg pays a great deal of attention to color in her reports, though it is often wrong. Ty gets vivid colors; when they are wrong, as often happens, the brightnesses seem to be correct—the color values are right. Some seem to be confused by color and do not try to remember it,[33] colors are right but apparently floating, loose.[34] Some of the color confusion appears to rise from association; intensification of color and finding it where there is none, from a sort of getting into the picture—a process which seems to involve motor imagery. A makes many errors in colors, due to dependence on naming and association, and probably also to lack of good color imagery. With S color is

[33] R. "Colors mixed me up." "A lot of colors, reds and blues etc., didn't bother with it."

[34] S. (Japanese scene) "Confused picture of yellow and other colors rather unusual in buildings, can't name any color surely but yellow though—curving lines of bright yellow stand out distinctly."

merely a secondary consideration, and so probably a weak image. In general, those who have seemed highly visual in other ways are good at color. Sc is not so good at color as might be expected from the objective results;[85] B is rather better but reports "not much color in 2″ exposures." It is difficult to know whether to class a tendency to intensify color and to see it where it has not been as an indication of good color memory or the reverse; it certainly indicates the presence of color imagery, and perhaps a weakness in holding visually presented factors grouped. T, who seems pretty purely visual, is perhaps the most accurate in her color reports; she is habituated to making fine color discriminations in scientific work. Grouped roughly as to color imagery: H, Ty, T, Ev; By, E, Y, Sc; Rg, B; R, A.

There is a great deal of variation, too, in the distinctness and accuracy of visual imagery. S affords as good an illustration as any of lack of distinctness or order in the image.

S. (10″ exposures.) Street scene: "Got general picture when trying to write down, white and black dots (hats, shirts, etc.) dancing or floating around during reproduction."

Animated street scene: "Street empty."

Street fair: "Visual images danced around." "Child could go as well in one place as another."

There was, however, considerable difference with this subject between 2″ and 10″ exposures. For 2″ times, she reports that she "saw pictures quite plainly when recalled, pretty well as a whole." The explanation for this I should find partly in a real lack in definiteness in visual images, an ability that could easily be overtaxed, and partly in the effect of the ever present associations in the 10″ exposures for which there is no opportunity in the 2″. The following example will bring out this last point as well as the others.

(10″ exposure.) View of Washington apple picking scene. "Saw trees and people in general way—conscious of reds and yellows. Saw man and said to myself 'picking cherries,' thought of a cherry picking I had witnessed (vague visual image of

[85] Sc says he can match colors well but has difficulty in remembering the names. He probably neglects color names.

tree, but more a half motor or locality consciousness of being somewhere else—to the right—where I had told yesterday about this experience, locality not accurate). Then looked to see if they were cherries, saw that they were too large and said to myself 'tomatoes'...had a locality sense of apple picking in Oregon. Deliberately counted people, noted sizes and order. In recall: the general mass was visual—used eye motor. Saw diagram of trees and people—sometimes three, sometimes four."

At the other extreme of definiteness:

Y reports that she "sees pictures perfectly."[36]

R reports that he can "call up and see as vividly as he wants to."

T. Japanese scene—"pine trees, conifers, mostly green. Trunks of two at entrance brown, sunlight striking them from above at right. Spot of brown on needles of left center tree. Couple of yellow green splotches on the green trees...."

Ev. (Mountain range. In sepia.) A mountain in the background. The side that slopes toward the left foreground slightly cut up by gullies. Toward the top the mountain is lighter, perhaps from bared rocks or snow, and this lighter part extends down in streaks, emphasizing the formation before spoken of. In the foreground several trees; in particular one to the left center, whose branches sweep toward the left as if the prevailing winds had been in that direction. At the right edge of the picture the branches of another tree—or trees—extend into the picture as if influenced by the same prevailing winds. A little back of these trees is some sort of a dark plot (right

[36] There is not in these recalls of picture postals any such "revival of personal attitude and emotional value" as Woodworth mentions as alone "enough to create a strong atmosphere of reality." (Woodworth, R. S., A Revision of Imageless Thought, p. 16) Y's introspections show very little or no feeling, the presence of which, under these conditions, usually involves the revival of a picture much more changed by associations than any of Y's. I have found a small number of observant people, outside my subjects, who feel sure that their recalls are as vivid as the original experience, though I suppose none of them would claim the presence of much if any content not noted—paid attention to—at the time of observation. The lack of such addition would not, however, prevent the recall's being as vivid as the original experience.

center) that I could not make out. (Direction—Write a description.)

By. (Glückliches Neujahr. 10″.) "Glückliches Neujahr" is printed in large black German type about an inch and a half from the bottom of the card on the right. Three musicians are standing before a stone house, in the snow, which has a bluish tinge. They are dressed in quaint but not antique costumes. The one on my left was playing a violin, the middle one with his back squarely presented, standing on one foot in a square patch of yellow light coming from the window of the house above them, plays a horn with a wide end. The one at the right plays a flute? or fife. There is a door with stone steps covered with snow, partly out of the picture on the left. The grayish surface of the house is streaked in an irregular pattern with white lines. On the right beyond the musicians is the corner of the house where there stands a post about three feet high. Foot prints go around this corner. In the background on the right is a house with reddish light windows and walls of greenish ? white, and partly obscured by it a church with a single square based steeple, also showing reddish light from the windows. The clothes of the men, the walls, and everything but the snow, are in varying shades of what seemed a mixture of green, purple and blue. (Subject was sure he would remember Christmas tree, but forgot it.)

H. (Glückliches Neujahr. 10″.) Three jovial little Germans playing the New Year in before the closed door of a little stone or stucco cottage. A light shines from a square window upon the snow, and falls in a bright yellow patch just where the middle fiddler is standing. The window itself is glowing orange with the light—the top of a little Christmas tree shows in it. The fiddlers' knees are bent—partly playing, partly excited, partly cold. A trodden path in the snow leads to the right around the corner of the house. A stone post stands there. Beyond to the right a wall, over which long lovely sprays of bare twigs (long pause) exist against and toward the sky, projecting upward and toward the right. There is another small stone building to the right. The words are in the lower right hand corner, Glückliches Neujahr, fancy letter placed in careless 'artistic' effect. (Sees picture: Oh—had a feeling that it was a church. Just ordinary German script, too. Highly idealized the twigs, didn't I? I got a strong sense of life from the picture.)

Sc. (Glückliches Neujahr. 10″.) Three musicians; violin, left, side view; horn, back view, end of horn showing at left; sort of flute at right, players left side turned. All dressed in dark clothes. House with arched doorway at left. (Drew it.) Four (should be six) -paned window at right of doorway, shut or open, window lighted, green tree inside. Foliage showing above house wall further toward right, had flat look. Beyond that a sort of street with windows lighted. Perhaps a little churchlike structure. Snow. Glückliches jahr?
tag

The difference between an idealized picture and a simply accurate one is shown by the two descriptions of Glückliches Neujahr by By and H, given above.[87]

It seems impossible to separate visual-motor, and to some extent other motor, from visual imagery. When relative position, direction of curves, elevations, and so forth are learned, eye-motor would seem to be a factor, though a sort of right and left movement, perhaps of the hand, or a feeling of positionness in the whole body, are often present. A seems to depend very consciously upon eye and head motor for every thing of the sort. The following are quoted as typical introspections where there is special attention to line and position.

By. "Always get lines before color."

R. "Get relative position, right and left, by slight movements, noting in mind that it is right or left." Subject ordinarily used his hands freely in describing, to show me how things were.

Ev. "Sort of localization of memory, getting general light and dark of whole picture. As soon as remembered this got fairly definite form."

B. "Picture not well balanced." "Got balance of picture right and that helped in recalling."

[87] Page 39. Ty and Y illustrate this point further.

S. "Named something whose locality, at bottom, alone remains."

The feeling of localization that comes out in the introspection on the apple picking (S), and the feeling of being in the scene of a picture, the vivifying of it, seem to be, at least in part, dependent on motor imagery. H is *in* the garden (of a black and white print) where she finds colors, sun, and warmth; with respect to her view of mountains she "was as much there as anything." Clearly kinaesthetic and tactile appears the following: H (portrait of a lady) "felt the pearls heavy on her neck." Of those who appear to be most motor in this way A, R, H, and B had been diagnosed as eye-motor and motor in preceding tests. There was a tendency to draw, which seems motor, on the part of almost all. It was very marked with Ty, almost as much so with Sc, Ev, and B, even showing a little with S.

A good deal seems to be retained by means of what are described as feelings, attitudes, impressions.

S. Got a beautiful aesthetic impression.

H. The second effect was of artificiality and cheapness in the print. Felt pomposity in man on ladder. (Of a church interior) The effect is Baptist.

Ty. Impression of man with back to me was of fatness and roundness and jolliness. (Of another picture) Had a pleased feeling.

A series of recalls was taken one week later, to see (1) in what way the cards returned to consciousness; (2) how clearness, accuracy and fullness of detail in the delayed recall compared with that in the immediate recall, which is from something almost like an after image; and (3) in what form or forms this detail occurred.

Sc. When asked to recall last week's pictures, he gave them in almost exact order of presentation and said when asked how he recalled them that he *saw* them. When questioned he said, "Oh yes, I just saw the pictures." He indicated them, too, by what was more a description than a title: The little girl sitting on the rocks; The New Year's one with the three musicians.

R. (2″) Church interior. It came back first through a motion he had made with his hands when he was explaining the line of the pew backs. The Runaway. "Horses came first, probably visual. Then things jumping up all of a sudden, heads, etc. Then the word 'horses.' Picture became clear and picked out details." Port Austin. "Girl on rock." "I probably got phrase first."

(4″) Futaara. "Saw gate very distinctly." Christmas Booths. "Lighted booths." "I probably got phrase first, or two together."

(10″) Italian Lady. "Saw face, picked out words and got details. Remember didn't like face very well."

Ty. (2″) "Remembered phrase 'Lincoln's Inn' before recalled the card. Then I recalled something unpleasant." (Later recalled Church Interior in this connection.) The Runaway came up in its composition and atmosphere.

(10″) Canongate came first, saw the card before got name for it.

E. Remembers for the most part as if she had drawn them and could look at them again. True of both immediate and delayed recall. Colors pretty distinct but not always sure it was the right color. "Recalled people buying Christmas toys at brownish booths with lots of light inside them. Visual first."

Rg. "They come back rather hazily as pictures before any names come." (Borne out by the way she names.) "Next is color tone of the whole, before individual figures seem to come."

In all but three cases of the eleven subjects tested on recall the cards seemed to come back first as pictures. With R and Ty, phrases used seemed to have occurred first for some of the cards; in one case R recalled by motor means; B does not know how hers come back. To Y, By, Ty, and A, the images of delayed recall seem firmer and clearer than those of immediate.

Y. All these pictures are infinitely clearer now than they were the first time. Writing out and checking up enforces details. I see them perfectly.

Ty. Can see some of these much plainer than the Japanese one (Nikko) I just had.

Ev. In general I see the pictures almost as clearly as I was able to see them a minute or two after picture was exposed.

Degrees of accuracy and fullness, and the character of the detail are shown in the following statements and introspections. Sc reports that he thinks of details now that have been in mind all the time, called up now perhaps in connection with the same things they came up with before. He thinks he was aware at first of two related details, a and b, a—color of trees, b—shape and probable kind; then became interested in expression of a, and when he had expressed it went on to c. In the delayed recall Ev thinks of points which he did not consider in the first recall, and which he is, therefore, sure of as really visual memories, that is, not aroused by a verbal memory of the other recall. When he sees the cards again he finds the colors brighter than he remembered them. A's recalls are good; he adds details, and though apparently first recall is not, delayed recall seems to be from a visual image. In immediate recall the process was "primarily one of naming. After the name came usually some vague and fragmentary visual imagery. Position came largely in head- and eye-motor terms." B has a visual image of the card in mind during recall. She thinks her visual images are built up quickly, more a checking up process than a remembered whole,—in which respect they probably resemble A's, and possibly R. S. Woodworth's.

Ty. Fröhliche Weihnachten is growing more comical.

Y. (Seeing card again after delayed recall). It is prettier in recall than the original.

Rg. When I see these pictures again they are very different from what I recall. For example, I read in backgrounds from other pictures.

Sc. (2″) Port Austin. Immediate recall: Lake fills most of left and distance. Strip of land going clear across, back at horizon. Not much sky. Right foreground, girl, white dress, on jutting rocks. Back of her toward background, wharf, sort of landing. Building to right, back of that woods, foliage, or something of the kind. Lake is still. Building white. Color of sky, lighter than lake. Seems to me had impression of hair ribbon. Second exposure: In memory lake was a good deal deeper blue. Didn't see printing at all.

One week later: Little girl in white, on rocks at right front of picture. Dark hair ribbon, feet dangling over rocks (verified in second exposure). Back of her, large white building among dark trees. To left of buildings a sort of wharf extending out into the lake that takes up most of the center and left of picture. Land behind the whole of lake. Narrow strip of sky. (From second exposure: lake rather light blue, not bright. Reflection below large white building makes a sort of light green patch on water. Trees, one at least, seem to be pines. Noted that rocks took up more of picture than I had thought.) While looking at picture first time looked for boat, because of lake. (Described "from the mental picture.")

Ev. (2") Lincoln's Inn. Immediate recall: After a few minutes' conversation on something else subject remarked that he had completely lost the memory of the picture. "General dull colors (dull was what they were) came back, pretty much as a whole. . . . Nothing apparently started it, was trying to remember whether it contained animals, people, faces."

First description (April 29): Very dull subdued color as in a fog. City street, walls of some sort rising from edge. Looking down it, an arch across it. A large opening under the arch for the roadway and a smaller one for the sidewalk at the left. I think there was none for the other sidewalk. Arch flat on top and extending clear across. (Correct.)

No second exposure.

Delayed recall (May 6): A foggy scene, or night scene, in London. There was an arch across the road that ran back into the picture. A small archway over sidewalk at left. Some sort of walls on each side of street. I think there was some dark substance—probably foliage—appearing over the fences. Colors were dull grays and browns—with a slight grain as if made by crayon on toothed paper. (Introspection: Largely visual. Fact that had written something before had great effect in helping to organize—does not bring back particular words. 'London' was firmly impressed, but thinks not necessarily or purely as a word. Good sketch accompanying, of gate and its relation to street.)

A. (2") Port Austin. Immediate recall (May 5): Water on left, light blue in color, went to edge of picture on left. Straight back of water an irregular outline of trees. In foreground just to right of center was a young girl seated on rocks. Rocks dull slate color just like natural rocks.* Girl wore a white dress, short, just below knees, white stockings and shoes.* She was sitting slightly facing me but more towards the water. No hat, hair down her back, not in a braid, but gathered at the neck. The rocks extended for some distance past her and to the right foreground. In the background was a rather spread out two-story and attic white cottage. Ordinary peaked roof with a couple of dormer windows. Eight other windows. In front of cottage was a pier extending fairly far into the water. In the background was an irregular line of trees. (Said he had forgotten roof was red. The print in upper left was red, the roof was not.)

Delayed recall (May 12): Left foreground—light blue water, lake extending some distance back. Left background—irregular line of trees on skyline. Right foreground—clump of rocks rising very rapidly to the right. Seated on rocks at water's edge, looking into water but facing slightly towards subject, a young girl. Dressed in white miss's frock, short, white shoes and stockings.* Hair hanging down her back loosely* but bunched at nape of neck. No hat. Right background towards center—a two story and attic white house, rather large, partly hidden among trees. Several windows visible, six or eight. Seems to be red trimming about the upper part of the house,* two chimneys. V roof. In front of house a rather long pier, dark gray in color, extending into the water. The top of it is not very high above the water. In the background more trees. No boats visible on this water.

* Errors. It is perhaps noteworthy that B, A, and S, who report least concrete imagery in learning, and most unanalyzable content—S many "associations"—are most inaccurate in recall. Definite concrete imagery may be a factor in accuracy.

The other introspection, besides those on delayed recall of cards, were examined carefully for verbal imagery, for purposes of diagnosis. Results from the introspections on cards follow.

No verbal imagery reported at any stage: Y, T, E, Ty (Counts and pays a good deal of attention to print.)

Y. (2″) Port Austin. The red of the printing appeared in the house roof. When asked if she named, in Nikko, where naming for identification would be likely to enter in, says no. In recall calls up card "edges and all." If while looking at picture shuts eyes, opens and corrects, gets better results.

T. In recall of Kittitas (10″) got both men on ladders. After recall of Fröhliche Weihnachten (2″) said on seeing card again, "The little boy is bigger in my picture." In 10″, got a general impression, then went after details. Thinks no naming. In the second 2″ exposure, knew it was 2″ and didn't try to take in too much detail or wouldn't have got anything. Thinks no naming.

E. Several times while looking at picture talked about something else, which might be supposed to inhibit a naming process if it was articulatory.

Ty. (4″) Fröhliche Weihnachten. The trees are scraggly, some kind of pine, and seven in number. Subject reports that she is attracted first by color brightness, then by anything that tempts her numerically, then by print if there is any. Says she doesn't think of names.

Verbal imagery reported for 10″ exposures, little if any for 2″ exposures: S, B, Sc, Ev, H.

S. (10″) Photograph. As I looked I said, "She looks like Inez." May have said "hollyhocks" and "arbor" to myself but seeing it so much at the same time that I am not sure. As I started to write about things words would come into my mind. Subject thinks that vague words are indications that she was trying to remember. She says, "I got sort of picture of another garden with holly-hocks and was conscious of the name of the flower. Nikko. Read its name and said it to myself. Just saw the rest. Tried to find something I could "light on"—I suppose with a dim hope of naming and thus remembering, but gave myself up to confused impression of colored pavilions or something of the sort. Brighton. Saw things and said "aeroplanes." Saw they were flags before said it—without naming. Then called them "flags" from sense of duty because had miscalled. Fröhliche Weihnachten. I remember I called child "dear little angel." Don't think I named Santa Claus until trying to recall.

(2″) Port Austin. Read the print, just plain looked. Interior of Church. Counted the windows, didn't name anything. Lincoln's Inn. No verbal imagery. Runaway. Word "hunt" came in recall, possibly when looking at it.

B. (10″) Mountains. Method verbal. Used phrases rather than words. Used visual to check. Futaara. (Asked to get colors.) Remembered "blue roof," "pink tree," etc. Learned by words, visual recall. Christmas Booths. Much naming. "More anxious I am to remember definitely, the more I tend to name."

(2″) Port Austin. Didn't name anything. Didn't see much detail. (Drew pretty accurate diagram.) Interior of Church. Got picture from visual after-image; continuation of old process rather than new one set up, practically lengthens exposure. In 10″ exposure had time to depend on other things and so did not need or notice the after-image.

H. (10″) Thinks from experience of forgetting details that she was "going to remember" that "you must just passively soak it in, or you'll get the details separated."[38] She named occasionally for identification.

(2″) Detail much cut down, just look with no thought of words. With 10″ more apt to notice separate factors and to name a few things or colors.

Sc. (2″) Has tendency to sketch.

(4″) Lincoln's Inn. Named things to himself—"arches," "two," etc.

(10″) Nikko. (Given spontaneously as comment.) While learning card was trying to find out what the things were, to find names. If material had been familiar thinks never would have been conscious of naming process, would have perceived picture and got the names so close together that would not have been aware. Names, as a device, unimportant things "that you think

[38] A surprising number of cases occur where mental reservation was made to remember an important thing and it was forgotten. (R, By.)

you'll forget." Puts down not so much what he sees as what he *remembers*. By the time he has written a bit he has forgotten all sorts of things that he saw. But he does not seem to be relying very much either on verbal images.[89]

In these cases it would appear that the increase in the time accounted for the presence of verbal imagery.

Noticeably verbal: A, R, By, Rg.

A. (2″) Process was principally one of naming; good deal of eye and head motor.

(2″) Lincoln's Inn. Sunset snow scene, looking into the end of a street. Street stopped with a high red brick wall with a gate in the center. Past the wall were the outlines of several brick buildings. To the right of the picture just to the right of the wall was a larger irregularly shaped building, noted for its large and frequent chimneys. The buildings towards the foreground were smaller. To the left of the end wall were a few low buildings hidden behind another wall like the end one. Sidewalks on each side and at the end man standing on side walk near gate at end. Some small trees lining street. Street itself appeared white as if covered with snow. About usual width. List of words used in learning in so far as they could be recalled: wall, red, gate, house, hump, trees, street, snow, dark, low.

Recall: Street scene. Dusk. Snow on street. End closed by fairly high brick wall. Gate at center. Man standing near gate. Street lined at end and both sides by small trees. Beyond end

[89] There is a resemblance here to Woodworth's experience. "What I got was sometimes to be called an image and sometimes not; but in all cases, with a few doubtful exceptions, it consisted of facts previously noticed. When I say 'facts,' I do not mean verbal statements of facts, but a direct consciousness of some thing, quality, relation, action—of something which I had observed in the original experience. I did not get back experiences as concrete totals, but only facts which I had discriminated out of those totals. In the original experiences, those facts had had a concrete setting or background; but this setting was not recalled. The facts were recalled in isolation." (R. S. Woodworth. A Revision of Imageless Thought, p. 12.). It is possible that Woodworth does not enough consider the probability that he is of a particular—and that perhaps a not very common—type.

wall some rather imposing stone buildings. On right some rather large buildings hidden behind wall. Many chimneys and chimney-like structures. On left, continuation of end wall and behind it some more modest buildings. Street has curbs and walks at both sides and ends.

(4″) Wrote out lists of words used, got fewer than he expected.

(10″) Got more of general effect, actually reported fewer details.

R. (10″) Canongate. Made a note to call them Highlanders —name too long to use. Photograph. Named, visual to check.

(2″) Got geometrical plan first. Then filled in. Naming occurred in placing details.

(4″) Christmas booths. Got a chance to visualize it more. Futaara. Naming, nothing motor about it, association aroused in cortex. In recall, see my plan of the picture, don't see words.

(10″) More naming and more visual.

By. (2″) Interior of Church. Word 'vaulting' came into mind. If a thing may be one of two things, if identification enters in, naming takes place.[40] Nothing else he would call naming here. Lincoln's Inn. Named "gate," "Gothic," "snow."

(5″) Portrait of a Lady. Naming process.

Rg. (2″) Port Austin. On seeing picture tried to see it vividly enough to keep after picture in mind. Recollected as an entire picture, picking out one detail after another in writing of it but seen as a whole. Interior of Church. Remembers saying, "red printing in corner, gray pews." Otherwise seen as a picture while writing.

(4″) Fröhliche Weihnachten. Probably articulated the German words, and the little hills were seen separately. Lincoln's Inn. Said title to herself as saw. Apparently no other naming. Rest of picture stays easily as visual.

(10″) Try to burden my mind with more details now you are showing them longer, sort of bothers me; I go from point to

[40] Ev. (10″) Nikko. Named somewhat, rather for purposes of identification than for memory.

point in the picture, more a series of details than a single impression.

By and Rg are not so verbal as A and R. With R and Rg there seems to be more naming with the longer period.

The differences for the different times in methods of learning and recall come out in the introspections. In general two seconds were too brief for a clear impression, in several cases too brief to get significance (T, B, Ty, S). It was in this exposure that such errors were found as the red of print appearing in the roof of the house. The observer gets general lines or masses, and color effects and has a tendency to use after-image to lengthen time (B, A). In the majority of cases (8 out of 13) no naming was reported for the 2″ times, although one subject (Ty) counted and read print in that interval. Of these eight, four report no naming for 10″ exposures, the other four depend upon it somewhat, especially when the matter of identification comes up. Of the four (Y, Ty, T, E) who report no naming all are markedly visual types in the other experiments; of the four who name, two (Sc and H) are good visualizers, also good verbal types, and two (Ev and B) are weak visualizers, one (Ev) very verbal, and the other uncertain—a highly articulatory type when learning words, but apparently not especially a user of words when the material is concrete. In the cases where naming was reported for 2″ exposures four (A, By, S, R) are verbal; Rg is neither especially verbal nor especially motor, is on the contrary, visual-concrete and auditory; S and By for 10″ periods can not be sure whether they name or not, certainly they do not name freely or as a conscious method. It appears probable, moreover, that A, who reports most naming and most definitely, overrated at least the extent to which words were clearly formulated. There is clearly some tendency for verbal imagery to increase with lengthened exposure.

The relation of the 2″, 4″, and 10″ periods is expressed by the group using verbal imagery as follows: A, opportunity to add words in 4″ (in 10″ he really got a more general or a more confused impression, the statements are more general and the count goes down); R, 4″ gave a chance to visualize it more, used scheme to save time, naming elements, 10″ meant just more visual and more naming—no change in method; Rg, 4″ stays easily as a visual impression, 10″ gave more a series of details than a general or unified impression. Verbal seem to have been a poor method for Rg. The non-verbal group reports as follows:

Y. Method same for 2″ as for 10″, but with 10″ had time to be conscious what I was doing, to think how I would write them down—I think it doesn't work very well.

T. Cannot grasp a picture in 2″, succeeds much better in 4″, loses in 10″, probably from association.

H. Detail much cut down when have 2″, just look with no thought of words; with 10″ notice and name separate factors, really remember better when I don't get details separated but just passively soak them in. (H increases number of details considerably between 2 and 10 seconds, but per cent not at all.)

The one great difficulty for the visualizers, and for some at least of the others, in the 10″ interval seems to be that time is given for many associations with other scenes and pictures, which results either in a new group-organization often involving idealization, or in confusion.[41]

The 4″ period seems to give the best results as a whole. There is time to grasp the picture, especially for the slower visualizers; the more purely verbal do not seem to gain much by the longer time, if anything they lose, like A; and it does not give time enough for the unity of the impression to be broken up or for confusion or idealization to take place through association. An occasional visual-verbal like Ty may increase the number of accurate details in ten seconds, but so far as the reports go it is at the expense of a great many errors. There are certainly twice

[41] H. (pp. 32, 37) Of one picture reports that she was "there," of another, "confused with the other Japanese picture." In one black and white print she gets color, sound and sunshine into garden scene.

S. (p. 33) who depends more than any of the other observers on associations and relations, is "reminded of another picture"; "'saw another garden"; "thought of a cherry picking I had seen."

R. (p. 32) reports a blue sky in a sepia print; says he doesn't get into the scene to see and feel things except during the longer exposure periods.

as many errors in 10″ as in 4″ periods, and practically none in 2″. Errors appear to be largely due to association by similarity, which takes time, and are much more common with visualizers, though there are individual differences. T (visual) and By (mixed), I should characterize as accurate types, perhaps inclined by habits of observation to keep entities separate.

Visual concrete imagery and the single impression,[42] judged by the effect of the 2″, 4″, and 10″ times, would seem to have the advantage over a verbal, analytical method. In the first place, the least visual, A and S make not only no improvement in the per cent of details learned, but show actual decreases of 10% and 8%. Rg and H, who though good visualizers use a somewhat verbal and quite analytical method on this material in the 10″ periods, make no improvement; both report confusion in the longer time. Sc who also employs verbal imagery quite deliberately in the 10″ period, though a good visualizer also makes no improvement from 2″ to 10″, although in the case of both Rg and Sc the data for 4″ shows a decided improvement. Y, one of the best visualizers, reports that the 10″ period gives her time to consider how she will write down her report, which she thinks is confusing; she makes an improvement of only 3%. Ty, also one of the best visualizers, with a strong tendency always to consider how she will express herself in words, though she increases the absolute number of details learned, makes a proportional gain of only 2%. By, E, T, and Ev, all visual, and all habitual users of visual imagery wherever possible, except Ev, who can use it and who makes the least improvement, made an average improvement of 14%, without Ev of 17.5%. These four, so far as the introspections show, used no verbal imagery in learning, and recalled from a visual image. B and R are the exceptions, with per cents of improvement of 10 and 15.5. B, though she does not seem very visual, nevertheless recalls from a con-

[42] B reports that she "learned details (10″) verbally, visual didn't stick, the more anxious to remember definitely the more verbal." But thinks she recalls from a visual image "built up quickly, more a checking process than a remembered whole." These visual images, built up later from a verbal and unanalyzable learning process, a "noting" of details, are different from the "single impressions," the "soaked in" details of the visual learner.

structed visual image to a considerable extent, and supplements visual by motor and by "meaning" as well as by words. R uses a mixed and very methodical visual-motor-verbal method and improves steadily, 2″ 42.5% of details, 4″ 51%, 10″ 58%. T, Sc, and Rg make their improvement, moreover, in the 4″ interval. Unfortunately there is no 4″ record for Ty, By, Y, and E. It would appear from this that a 10″ time, in addition to allowing the formation of confusing associations, allows for a use, with some subjects at least, of verbal imagery and analysis which do not aid in the learning; the purely visual unity is broken up and no other has time to form. A visual method, if it is not confused with others, makes for improvement in this interval, or probably in the 4″ period. The verbal type using a verbal method makes no improvement and may even fall back; the visual type using a verbal method does improve markedly; the mixed type using a mixed method also improves.

When we come to the consideration of the percent of details[43] remembered, the absolute standing in the whole experiment, what seem to me to be very interesting correlations between success and method appear. The least visual, A and S, get the smallest average number of details and the smallest per cents; they also get "a general effect," blurred, for 10″; both of these subjects have many errors. Sc, Ty, and Y, excellent visualizers, with a strong tendency to use verbal in long times, make very high records and make them immediately, in 2″ to 4″ exposures. T, visual, though not making an especially high record, makes it by the end of the 4″ period, improving 10% between 2″ and 4″. E and By, excellent visualizers, E very slow, make their high records by the end of the 10″ period, and unfortunately have no 4″ records. Ev, H, Rg, not so efficiently visual as the others, make their good records immediately—all of them, like Sc, Ty, Y, tend to use verbal, especially for the 10″ period. R and B make good records by the end of ten seconds, R by a mixed visual, verbal, and schematic (motor?) method, B by a mixed method involving some visual, a good deal of motor, verbal, and "meanings." On the whole, the more purely visual method seems to give a greater

[43] See Table, p. 31.

number of details in a short time, to be quicker and relatively more effective than any other. Visual is also quicker where not so relatively effective. A good mixed method, like R's, if methodically handled, is effective. A fragmentary visual picture is not integrated by S's associations and comments, nor by A's vague 'naming.' Association is slow, and confusing within these time limits. Motor is slow—R and B and possibly T. Verbal, probably because it involves analysis into details, is slow and confusing.

The test leaves the subjects in three or four groups as to visual imagery: 1. Ty, Y, By, Sc, E; 2. T, Rg, R; 3. H, Ev, B; 4. A, S. Of these, R, B and H are motor, probably also Y and T; Ev, A, S, Sc, R, the most verbal, though Ty, Y, and By use verbal imagery occasionally. T, E, and A appear to be the least flexible in type.

Correlation between 10″ results, and visual type as previously shown.

Type	Subject	Per cent of details
	By.	70—80
	Y	60—70
Highly visual	E	60—70
	Ty	60—70
	Sc	60—70
	T	50—60
Good visual ability	Rg	50—60
	R	50—60
	H	40—50
	Ev	40—50
	B	40—50
Weak visual	A	40—50
	S	30—40

Summary.

It seems evident that the imagery used varies greatly from individual to individual, and from task to task for each individual. Yet the results show a pretty steady and habitual use of imagery on the part of the individual subjects, an imaginal type, or type-group which can be fairly clearly determined. It is not, perhaps, possible to classify people into a small number of fairly definite groups; but it is possible to become pretty definitely acquainted with the imaginal habits and capacities of any individual, and to describe him as more or less verbal, more or less visual, flexible, or many-habited or capacitied, inflexible, or largely bound to one imaginal form. It seems probable, too, that he may be described as more or less imaginal; that is, he may have more or less mental content which, if it is imagery at all, or imagery as ordinarily conceived, is so complicated or syncopated or vestigial or otherwise unanalyzable that the subject can not lay a finger on it.

There is a great deal of imagery other than verbal, accompanying or even displacing verbal when verbal imagery seems called for by the nature of the material. Verbal imagery, moreover, seems to be of a very fragmentary character in most instances where it does occur. The relation of the idea or stimulus, verbal or other, to word is so automatized that in most cases no image of the word supervenes. Judging from the introspections, thought often takes place in concrete imagery,—which may be, and in fact usually is, except when difficulties of some sort arise, of a very syncopated, or possibly liminal character. In fact, thought apparently takes place clearly and in high forms, without the appearance of anything that can be said with certainty by the subject to be imaginal at all.

The free word-association test which follows was originally intended to settle, if possible, a number of questions raised in these diagnosis tests. When verbal imagery and reactions were undoubtedly stimulated by the conditions of the experiment, would visual or other concrete imagery function, would the concrete imagery precede the reaction word or direct its choice? Particularly, would a relation appear between this functioning imagery if it occurred, and the predominantly imaginal or nonverbal types? Then, too, if verbal imagery occurred normally before the response it would certainly come out in introspections here. Lastly, if meanings have a tendency to occur in imageless or unanalyzable forms it seemed probable that they would here, especially if rapidity of thought, and attention directed to other ends are factors in such occurrence. That is, this experiment was undertaken in the first instance for the sake of the resulting introspections, which would have the advantage of covering an extremely brief interval of time, when the attention was very definitely focused upon a task, yet upon a task that left considerable freedom to the subject to go his own gait.

CHAPTER III.

THE FREE WORD ASSOCIATION TEST.[44]

The free word association test, undertaken for the purposes stated at the end of the preceding chapter, has offered unforeseen opportunities for investigation of the function of words.

TIMES.

The first attempt to organize this material was an analysis of the reaction times. The times are given in sigma.

Reaction times.[45]

Subject	Total no. timed reac.	Av. time	Under 900	900-1000	700-1400	1000-2000	Over 2000
S	112	1182	33%	12.5%	77.7%	50%	4.5%
Y	108	1205	31.4	18.5	69.4	42.6	7.4
R	107	1462	15	8.4	48	62.6	14
By	97	1502	2	6.2	45	80.4	11.3
H	110	1558	10.9	10.9	48	56.3	21.8
T	104	1564	13.4	2.9	51	62.5	21.1
A	106	1589	4.7	11.3	49	68	16
Ev	103	1868	.97	1.9	38.8	75.7	21.39
B	105	2265	5.7	5.7	30	55.2	33.3
E	94	3356	3.2	0	9.5	20.2	76.5

Of the two very quick reactors, Y and S, S had previously shown herself a verbal type and dependent largely upon associations and comparatively imageless relationships for learning; Y up to this point had been predominantly visual, and in this test has visual-concrete imagery accompanying or preceding about 56% of the reactions, the visual imagery appearing to be very intimately connected with verbal. Unfortunately, neither of these subjects was able to continue in the later tests. Of the three

[44] See description of it in Chapter I and in Appendix.

[45] The total average of these times, omitting the somewhat untrustworthy record of E, is 1577 sigma, with E's average 1755. The total average of thirty subjects in Crane's work (Association Reaction and Reaction Time) is 1434. The increased time in this experiment may be due simply to the fact that there were fewer subjects; it may be due in part to the different character of the words in the list; or the greater average age, 27.7 as compared with 24.7, may have something to do with it.

slowest reactors, Ev and B have seemed quite verbal, though both have a great deal of comparatively non-imaginal thought content; E is predominantly, I should say abnormally, given to concrete imagery and is extremely slow in the use of words, though by inclination a writer. The investigator feels assured in her previous judgment that Ev, E, and B are essentially slow reactors; these times correspond not only with previous time records but with the general speech habits of the three. R, By, and H, whose times are shorter than the average, are highly verbal, with plenty of possibility of concrete imagery, mainly visual, with R motor. Of T and A, whose times are about average, T is rather visual and non-verbal, A verbal and motor—comparatively faded or vestigial imagery.

No clear correlations appear between these times and the type-groups as previously determined, though verbal predispositions seem to have an advantage, and predominantly concrete-imaginal a disadvantage. The times are, however, clearly related to the sort of imagery used in this test, and are valuable for the indirect light they throw upon some of the questions raised. In order to see if the presence of imagery affected the times, and if so, if there proved to be any clear difference between individuals in that regard, a comparison of the times for automatic verbal reactions and reactions clearly accompanied by imagery was undertaken. Twenty-five times chosen from different days, for reactions as clearly verbal and automatic as could be found, were compared with an equal number, or as near it as the record of the subject permitted, of reactions accompanied by imagery, with the preference given to cases when imagery clearly preceded. With E it was possible only to take the reactions that appeared, on the face of them,—through comparison with other records, etc.—to be most verbal; twenty reactions were finally chosen. Y's record provided only fourteen clearly verbal reactions. On the other hand, with Ev (7), A (10), S (8) and T (4) it was difficult to get any number of image-accompanied words for comparison; T has so few as to invalidate the result, though the four used are clear cut and trustworthy instances. The absolute differences in sigma are shown below, together with the per cents resulting from a relation of those differences to the verbal reaction times.

Subject	Verbal Reac. Times	Imaginal Reac. Times	Difference in Sigma	Percent[46] of Delay	Type as Previously Retermined
S	889	1101	212	24	Unanalyzable, verbal.
Y	949	990	41	4	Very visual.
H	1001	1451	450	45	Visual, other concrete. and verbal.
R	1102	1407	302	27	Visual, other concrete, and verbal.
A	1129	1552	432	37	Visual-motor and verbal.
B	1222	1979	757	62	Motor, and other concrete, verbal.
Ev	1249	1639	319	25	Unanalyzable. Verbal.
By	1263	1686	423	33.5	Visual and verbal.
T	1426	2038	612	43	Visual
E	2088	2975	887	42	Concrete imagery engrossing.

The per cents seem on the whole to give a truer basis for grouping according to the amount of delay. Y shows very little lengthening; meanings of the concrete sort seem to be habitual with her and her quick times would seem to indicate a very close association with speech (words). The next four, with a range from S, 24% delay, to By, 33.5%, are the four most clearly and highly verbal of the subjects. S and Ev provide very few usable examples of concrete imagery and neither appears to employ very much in reading. R and By are much more given to concrete imagery, but By, at any rate, does not use much in the reading of prose, though trained to use it for poetry. A, 37%, seems to have very little concrete imagery and to be quite verbal. These five are considerably delayed by the appearance of imagery but do not dwell upon it to the extent that the visually preoccupied E and H do (42% and 45% of delay), or T in the rare cases where it occurs. B with 62% of delay probably, like E,

[46] Crane, Association Reaction and Reaction Time, pp. 27-8. "The results of our experiments, while they cannot be definitely tabulated, indicate that as a general rule the coming, with the appearance of the stimulus, of a visual image tends to retard the reaction.

There are two general classes of visual imagery. There is a simple imagery, where nothing appears in the picture save the isolated image, generally of the object representing the stimulus word. There is a complex imagery, in which the picture represents a complete situation. In either case the natural result is retardation of reaction time." (p. 27)

T, and H, does not pass readily to verbal expression under any condition, and seems like them to be interested in her concrete imagery.[47]

The Verbal Element

The verbal element was then analyzed, on the basis of both the reaction words and the introspections. The following factors were classed as verbal: repetition or pronouncing of stimulus words, perseveration of words, verbal form of stimulus word controlling or influencing form of reaction word, a definite literary context or phrase relationship, synonyms (not so surely determined, dependent on introspection), and other very close verbal associations, of class or category, drab—color; tapir—giraffe, turf—jockey. These last are especially likely to figure in other counts, because they are most likely to be accompanied by concrete imagery, and in some cases are even preceded by it.

Subjects	Time av.	Gen'l Verbal	No. verb. phrases
T	1564	90%	15
By	1502	88	70
A	1589	88	59
S	1182	84	46
Ev	1868	82	23
B	2265	84	60
H	1558	82	63
R	1462	74	46
Y	1205	65	14
E	3356	39	14

These results would seem to indicate that Y and E are the least verbal in tendency, By, H, B, A, and possibly S, are most so. I have omitted T from this group because of the extremely small group of combinations that can be rated as verbal phrases—she appears to be much more closely related to E and Y, and previous experience bears this out. She is neither a ready talker nor a practiced writer. There is a great deal of doubt in my mind as to whether the more automatic verbal reactions, due to influence of stimulus word form, should be interpreted as indications of a truly verbal mental habit. They are not inconsistent with it, but it appears probable that the automatic verbal re-

[47] Y's imagery, to use Crane's terminology, may be described as 'simple,' E's as 'complex.'

sponse may be present where there is not an habitual use of word images in the thinking process. In making diagnosis it might be well to distinguish as far as possible between automatic verbal response, and internal verbal, or use of verbal images. The position of S would, for example, be considerably affected; for stimulus-word form, both through appearance and articulation, influenced a large per cent of her reactions.

The lack of correspondence between Y's quick time and her very imaginal results points, together with some of the results from Ev, to a difference between verbal thinking and the close relationship between concrete images and words which consists in a visual-concrete form of *meanings,* 'simple' imagery. Meanings for Ev are likely to be present in the form of other words or in forms for him imaginally non-analyzable. By, who had the highest record in previous verbal tests, has, if the number of phrases is taken into consideration, the highest record here. E and Y, who have previously shown most visual-concrete imagery, show least verbal tendency here; that is, words do not call up other words directly. Both talk a good deal at times, but very hesitatingly when thinking. H is verbal in previous verbal tests, and has a high record here. A, showing little concrete imagery in other tests, has a very high verbal record here. At the two extremes there seems to be a considerable amount of correlation between these results and the others.

The high record in definite literary context of S and H should be an indication of a high degree of verbal memory. The presence of literary vocabulary and phrase emphasizes perhaps nothing more than the literary background and wide reading of S, H, R, and E. The absence of a high record in the cases of Y and Ev seems to need some explanation; both would be expected to rank high. Y, however, in previous tests has shown very little preoccupation with words as such, and a poor verbal memory. Ev has shown a preoccupation with significance rather than with the words themselves. A tendency to give synonyms accompanied, at least, by consciousness of meaning, comes out with Y and Ev, and may account in part for the low verbal record, doing away with the more automatic response. Logical relations and predicative reactions appear very little in this test where a premium is placed on the more automatic verbal response —on the first quick reaction. R, A, By, and B show most evidence of this.

Parts of Speech.

An analysis of stimulus and reaction words as to occurrence and relation of parts of speech bears out Crane's conclusion[48] that verb and adjective as well as noun stimuli give a marked dominance of noun responses. Out of a total of 458 stimulus words interpreted as nouns 386, or 84%, brought noun responses. Out of 161 stimulus words interpreted as verbs 88, or 54%, brought noun responses. Out of 383 interpreted as adjectives (such combinations as grate—fire, wind—storm, maple—sugar, were considered noun to noun reactions) 286, or nearly 75%, brought noun responses. It is significant, however, that with the records of two of the subjects removed the above per cents become 84, 62, and 88. The per cents for these two persons, Ev and Y, are 83.5% nouns to nouns; 25% nouns to verbs as compared with 72% verbs to verbs; 17.8% nouns to adjectives as compared to 82% adjectives to adjectives. These two make respectively 43 and 38 noun to noun responses, 8 and 15 verb to verb, and 28 and 32 adjective to adjective. A great deal of this is to be accounted for by the tendency referred to above to give in response synonyms, or words of similar or contrasting meanings.

For example:

Y. Severe—hard, broadens—narrows, scarlet—red, animated—quick, comely—pretty, jeopardy—danger, low—high.

Ev. Severe—hard, broadens—widens, scarlet—red (six of the other eight give scarlet—letter), comely—beautiful, jeopardy—danger, low—high, animated—lively.

Compare with these the following typical records:

R. Severe—cold, broadens—mind, scarlet—letter, comely—girl, jeopardy—life, low—bridge, animated—life.

B. Severe—teacher, broadens—me, scarlet—letter, comely—

[48] Crane, Association Reaction and Reaction Time, p. 8.

maiden, jeopardy—Hair-Breadth-Harry, low—sweet, animated—cow.

Only one of the other subjects (T) approached the records of Y and Ev and much of her record can be explained by a tendency to reply with a word suggested by the visual form of the stimulus word (comely—homely, low—blow, jeopardy—leopard, animated—animal, inculcate—calculate, distribute—disturb), though there is no doubt also some tendency to keep responses in the same class (blue—green, scarlet—red).

It will be seen from the table below that 764 out of a total of 1041 responses were nouns. The noun being the simplest and probably the most thoroughly automatized part of speech, its predominance in the responses is not hard to understand. But the distinction that held above is quite as noticeable here; the total noun reactions for Ev and Y are 46 and 56, for T 65; for the others 80 to 91. Here, as elsewhere, Ev and Y show a less automatized word to word relation, Y apparently making the connection through concrete-imaginal forms of meanings, Ev through meanings of a comparatively unanalyzable sort.

Parts of Speech in the Reactions.

Subject	Total number reactions used	Noun to noun	Adj. to noun	Verb to noun	Total noun reactions	Adj. to adj.	Verb to verb	Noun to verb	Verb stim.	Verb reac.
Y	102	43	6	7	56	28	8	0	16	8
Ev	108	38	7	1	46	32	15	8	16	23
H	108	41	40	10	91	2	1	1	14	5
R	109	35	33	12	80	5	3	6	19	12
A	106	35	37	12	85	3	1	4	17	6
T	97	34	24	7	65	7	7	3	16	12
S	107	41	36	8	86	6	3	0	12	6
B	105	41	35	12	88	4	1	2	16	5
By	110	38	39	6	84	0	0	3	18	5
E	89	41	28	13	83	0	0	0	16	0
Total	1041	386	286	88	764	87	39	27	161	82

Concrete Imagery.

A great deal of concrete imagery was present in mind for some of the reactors during the time between the appearance of the stimulus words and that of the reactions, notably for E, Y, H, and B. It was notably absent with Ev, T, and A. In general, it may be said that a high degree of concrete imagery does not accompany a highly verbal record, though the converse does not appear to be quite so true. The common concrete imagery was, as would be expected, visual. R reported a good deal of motor, and B a little. The especially significant point here was the fact that in many cases the presence of visual or other concrete imagery undoubtedly preceded any verbal image or response.[49] The directions for introspections in this test laid especial emphasis on a strictly chronological and orderly account of the mental content.

Presence of Concrete Imagery.

Subject	No. of react.	Vis. prec.	Vis. accom.	Vis. fol.	Tot.	Other concrete	Tot.	% of react.
Y	107	34	11	1	46	14	60	56
S	112	0	6	10	16	—	16	14
R	113	2	9	1	12	15	25*	22
A	110	—	3	—	3	5	8	7
B	112	8	6	2	16	1	17	15
T	111	4	2	1	7	—	7	6.3
H	113	1	24	7	32	9	41	36
Ev	113	4	2	—	6	—	6	5.3
B	110	6	3	19	28	7	34*	31
E	96	50	40	1	91	11	93*	97

* Some overlapping.

E, who reports 50 preceding, was somewhat confused and is therefore not entirely reliable; but Y, By, B, and R give very clear reports, and Ev and T appear to have the same experience. In a considerable number of cases the imagery has to do directly with the reaction word. These subjects are certainly capable of employing other imagery than verbal under circumstances most likely to bring out verbal: the task called for words, and the whole situation favors a verbal response.

The following reactions illustrate the occurrence of concrete

[49] Compare Crane, Association Reaction and Reaction Time, pp. 27-29.

imagery connected with the reaction word and preceding it.[50] The times are compared with the average for all reactions where imagery occurs.

Y. (990)			
chill	snow	1375	Felt baffled, then a fleeting picture of a winter night brought the word.
Hall	corridor	759	A fleeting picture of the hall in North, then "corridor."
chattered	noise	1295	Picture of apple tree full of birds. Then big table at house.
enjoyed	picnic	1411	Had C. in mind so word brought picnic of last night up river.
lawns	garden	761	Glimpse of green trees, then flash of Vassar Circle.
By.			
mirror	glass	....	Visual image of mirrors, then a substance—"glass."
omnibuses	London	....	Visual preceding of street with busses, named "London."
streaming	line	....	Strong inhibition, image of banner.
isobar	map	....	Tried combinations of "therm." Vague visual image of isothermal map.
B. (1979)			
mirrors	light	1609	Faint ray of light reflected from mirror, had in Physics this A. M.
bell	door	2088	Door in mind some time before able to get word.
vagrant	tramp	6477	Tried to think of word in psychiatry. Visual of tramp but set for other word.
chattered	squirrel	2059	Auditory image, then word, then visual image.
R. (1407)			
quince	lemon	769	Saw succession of fruits passing. Saw before saying.
host	friend	1342	Saw host and party. Said "friend" to say something. Could have said *food* or *men*.
Ev. (1639)			
carrot	tomato	1827	Groping for some other form of vegetable. Tendency to color image.
T. (2088)			
dusky	dandy	1463	Creole gentleman—checked trousers, yellow tie, straw hat.
E. (2975)			
florid	carnation	....	Saw carnations, laurel colored and white.

[50] Crane, Association Reaction and Reaction Time, p. 27.
"No. 2. Ear-Lobe, 4.764 (2.688)
'Image of ear comes almost at once. Took some time to pick out what was going to say.'
No. 3. Activity-Mental, 1.667 (1.030)
'Image of a student at a student's table. When I see those images the word don't come.'"

critical (understood crystal)	crystal hanging things	4442	Crystal candelabra, lighted room.
Orpheus	harp	1643	Saw Orpheus with his harp.
severe	Miss McC	1463	Complete portrait in gray dress of Miss McC.
dive	poise	4219	Tense girl, poised for dive from board.

In a number of cases the stimulus word seems to excite both verbal and concrete imagery; often when there is apparently a quite automatic phrase reaction, the concrete imagery, to the subject's observation, appears not only to occur as soon as the reaction word but to precede it. This tendency would seem to indicate the habitual connection of concrete imagery with words. The verbal reaction average is given for comparison.

Y. (949)			
Orpheus	Eurydice	1285	Visual of youth in Greek costume, then a girl,—then word.
R. (1102)			
fly	paper	857	Saw flies on paper before saying.
humble	very	....	Thought of Uriah Heep. *Was* Heep but "very" came out.
grate	teeth	1716	Thought of fire. Grating teeth (motor).
E. (2088)			
rippling	brook	2664	Saw brook, foaming in woods. Sure image came first.
wind	trees	2390	Sound of in big pine woods. Sight of trees then word.
scarlet	leaf	1778	Maze of autumn trees by V. C. Lake. Leaves in lake.
Ev. (1249)			
Orpheus	Eurydice	1642	Couldn't tell if other person or word.
brook	trout	1815	Saw brook, then fish. Then got word combination.
courtsy	bow	1969	Confused image of minuet in colonial costume.

In the following case there is apparently excitation of imagery by the partially excited word.

E.			
carrot	parrot	771	Big green and red parrot laughing. Thinks it came first, at least came with "parrot."

What seems to be the presence of meanings in concrete form occurs for several of the subjects.[51]

Y.			
96 assimilate	gather	2641	A feeling of tension, of wondering why word didn't come. Then sense of something like lines getting together—then "gather."

[51] See V of Preliminary Group. Chap. II.

102 distribute	gather	914	A sense of scattering out. The minute I tried to remember it became a series of lines from central point—but I don't think the lines were there at first. "Gather" came quickly as if tension had been released.
sumptuous	rich	1328	Visual of shining colored fabric.
dusky	dark	1455	(Visual) Something opaque, soft, dark.
majestic	good	973	Vague picture of fairy king in robes.
H.			
jeopardy	Jepthah	1994	Always have thought of him with daughter in jeopardy.
severe	teacher	2118	Traditional teacher, my ninth grade one.
E.			
severe	Miss Mc C—	1463	Complete portrait in gray dress.
courtsy	man	1367	Elderly man in Louis XIV clothes taking off his hat.
eighty	cap	4008	Old lady in gray silk with lace cap.
B.			
severe	teacher	1447	Followed by indistinct vision of woman, tall hard jawed, with spectacles.
serene	day	4559	Day first word. Had idea of girl's face, not visual.

The following reactions illustrate rivalry of concrete images, another indication of habitually concrete-imaginal mental content.

Y.			
maple	willow	1036	Mixed idea of sugar and trees, both visually represented. Tree displaced sugar, then reaction.
dive	hole	1100	Associated dive with vagrant-robber brushed aside by paddle-canoe with picture of river with green banks. Same river.

VERBAL IMAGERY.

It may, on the other hand, indicate a verbal habit of mind when, as with Ev, By, and B, a verbal association will often break in and overcome a visual or other concrete image.

Ev.			
lake	river	1216	"The Lake" Winnepesaukee, "River" broke in.
chink	Chinaman	1372	Accompanied by consciousness that it was wrong. The chink of money was in mind.
B.			
chink	Chinaman	2277	Visual of chink in wall. Verbal came up and inhibited visual.
chill	fever	1369	Inhibition due to several things coming at once. *Felt* cold, said "fever."
By			
medium	hard	1435	Visual image of a steak.
low	bridge	....	Thought first of tide, but said "bridge" while *saw* tide.
bliss	Perry	1591	Vague idea of a state of being. Name came before could get word for it.

Verbal rivalry seems quite certainly to be an indication of a verbal habit.

R.			
courtsy	drop	2040	"Girl" came to mind first but "drop" got ahead.
also	ran	1538	Wanted to say "conjunction" but phrase came.
jeopardy	life	1139	Wanted to say "leopard."
Y.			
frog	oyster	856	Panic. Vague picture of marsh. Thought "fish" said "oyster."
due	money	898	"Dues" came half way up, then "money" quickly.
dyes	yellow	1066	Started to say "red" but "yellow" seemed to overtake it and get ahead.
H.			
chill	day	1552	Thought "November" (poetical association), but "day" came out.
quince	jelly	869	"Sauce," "blossom," "jelly" came most convincingly.
punch	bowl	1090	Thought "Judy," said "bowl."
piping	hot	1101	Thought of "Pippa" first. Couldn't resist "hot."
T.			
Orpheus	theatre	1596	"Muse" came vaguely.
medium	salt	2124	Thought "media" but it did not come distinctly.
S.			
maple	tree	1063	Pronounced maple. Impetus to say "bough"—not strong enough.
A.			
medium	price	1414	Was trying to think of "spiritualism."
enjoyed	time	1010	"Party" trying to emerge, but "time" beat it.
B.			
reading	book	1420	"Book" was not the word in mind, but it did not come up enough to be recognized.
Lake	Constantine	1803	"George" was in mind but would not come.
Ev.			
broadens	widens	1304	Hesitated. Words like "lengthen" threatened to come.
braes	banks	1671	Response delayed by struggle between beginning and finishing line.
bugle	bungle	1979	Read first syllable with short u. "Bungle" and "Burgle" contending.
By.			
hum	bee	1323	"Bee" from sound of "hum." Then "Vergil." Said "bee" with "Vergil" in mind

More automatic reactions tend to come for H, T, S, A, R, Ev, By; less automatic for Y and B.

Verbal meanings seem sometimes to occur.

H.			
maple	tree	941	"Maple" means a "tree."
gem	biscuit	1521	A "gem" is a "biscuit."

A sort of judging or logical influence is perhaps visible in the following, and seems to me to indicate a verbal tendency.

A			
broadens	roads	4777	What do they broaden? Roads.
remember	what	1222	Struck as a question. Wondered what was supposed to remember.
R			
remember	what	1372	Remember! What? Feeling as if had forgotten something.
broadens	mind	1362	Looked for thing broadens might affect.
chattered	monkey	1548	Thought of what chattered.
By			
conterminous	lines	1991	Finally got word by deciding what stimulus word meant.

An attributive or predicative reaction quite certainly indicates a tendency to verbal thought on the part of By, A, and R.

A.			
knifeblades	dull	1618	"Knifeblade is dull." Attributive.
lawns	mowed	918	"Lawn is mowed."

A great many reversed verbal associations (not like Crane's "backward running," milk, bread and) occurred, especially in the records of B and R. S has a number that are purely visual-verbal. In order to see if the reversal was accompanied by a lengthened time, averages of the reversed and of five or six as nearly unimpeachable verbal and similar reactions as possible were compared; a comparison was also made with the general verbal time average. This procedure showed a considerable lengthening of the time (108 to 378 sigma over the special averages, to 604 over the general verbal average) for A, Ev, H, By, R, and especially for B. It is perhaps noteworthy that the subjects who have most of these reactions are all among those whose time is lengthened; that A, H, B, and R, all in this group, have the clearest motor tendencies; and that B and R who are most motor show the greatest delay. Practically the same, or somewhat (greatest difference 78 sigma) shorter times, are shown by the visual-verbal S and by the visuals Y and T. E has a very much shorter time average for these verbal reversals (723 sigma), which I take to be an indication that these particular reactions are really and merely verbal. It seems possible that the auditory-vocal-motor types are most confused by such reactions and most liable to them.

Illustrations of reversed associations.

H. Special verb. av. 1357. General verb. av. 1001.			
low	swing	2175	("Sweet and low" in mind vaguely.)
S. Special verb. av. 885. General verb. av. 889.			
clock	o'clock	885	
low	bellow	877	
chattered	teeth	871	
A. Special verb. av. 1124. General verb. av. 1129.			
extract	Pond's	1098	
tide	high	1135	
B. Special verb. av. 1112. General verb. av. 1222.			
low	sweet	1500	
eggs	butter	1438	(Visual of flower "butter and eggs.")
By. Special verb. av. 1118. General verb. av. 1263.			
Hall	A. G.	2263	
jeopardy	put	1123	
dyes	diamond	1738	(Strong inhibition.)
R. Special verb. av. 1120. General verb. av. 1102.			
courtsy	drop	2040	("Girl" came to mind first.)
lawns	mow	1169	
culture	German	1239	
T. Special verb. av. 1216. General verb. av. 1426.			
fly	swat	1268	

Perseverance of word forms through several reactions occurs in a number of cases: Y, 12; S, A, By, and B, 7; R, T, and Ev. 5; and E certainly 4 (9 cases of repetition). In the case of Y it seems to be the indication of fatigue, the inability to check pure automatic reaction. For example, the word *good,* appeared quite naturally as a response to *savoursome;* it reappeared with *also,* where there is no other word to dispute its entrance and just after subject had said "I will be good"; with *majestic, spread, streaming, logical* and *chink.* At this point the test was dropped for the day. The word had become an obsession. Ev's experience with the word *black* is somewhat similar.

May 20.			
11 wind	blow	2697	For some reason had "black" in mind, had to be got rid of.
14 drab	black	....	Recognized as color word. "Black" disappointed. Had just rejected in 11.
20 silvery	black	1801	"Black" just came, distinct feeling of disgust when it appearedl.
May 27			
37 mirrors	shine	1558	Bothered again by "black." Think it may come from color of machine.

June 12			
84 grim	Mr.	2272	"Dark" or "black" conflicting.
86 dusky	black	1052	"Black" has been a very common word with me in these experiments.

It will be noticed that the word is not spoken in this case unless it fits. Even in the extreme case of Y there is the same tendency, as the following reactions show.

58 spread	good	1374	Food-taste-good.
61 streaming	good	1071	Pleasant image of flowing down line. Surprise at word.
71 logical	good	1184	Vague "hurry" of work on argument. Then the connection between logical and good seemed clear.

Later in the case of *no* the same thing occurs.

90 yes	no	933	
91 conterminous	no	3174	Did not seem to be repetition, asked self if I had seen word. Answer "no."

Whether it is that the word has a strong tendency not to come, or not to come completely (to be inhibited), unless it fits into the verbal or other association group, or that while it is coming the mind makes a frantic effort to have it seem sensible, I cannot say.

T.			
65 gold	golden (west)	2383	
68 arcade	gold	3636	Something about the word—rca—(possibly brocade) suggested mellow, rich color.

Here there was need apparently for such a word, and *gold,* being ready, came.

S.			
12 hum	bug	711	
34 humble	bug	1050	
A.			
12 hum	bees	1864	
34 humble	bees	971	Reports thought of 12 before giving association.
101 moist	day	1123	
108 serene	day	1679	Tried to get body of water, wouldn't come.

This case is, perhaps, more association than perseveration.

R.			
61 streaming	water	1723	Brought back 59, murmur-stream complex.

Pure perseveration.

By.			
35 carrot	top	1080	
36 bell	top	1002	

By's *it* is like Y's *good.*

19 remember	me	1590	
64 due	me	986	
76 analyze	it	1458	
92 Punch	him	966	
96 assimilate	me	1786	Very strong inhibition.
98 enjoyed	it	2161	Several personal pronouns in mind.
102 distribute	it	1579	Began to say "me" but refused.

These repetitions seem in some cases to be a sort of set, almost an Aufgabe in By's case, to respond with a personal pronoun to verbs. Certainly the place into which the word may come is pretty well controlled by whether or not it would fit there.

Types of Imagery Illustrated.

It is evident from the introspections given that the common imagery is visual. Visual imagery appeared profusely for Y and E, in considerable quantity for H and B, and somewhat for By and S. With others it was neglible. It occurred before the reaction word for E, Y, B, By, T, Ev, and R. Visual-verbal imagery occurred occasionally for Y and By, at least once for R, B, and T. S from the time she "got a suggestion of 'stone' printed after 'cling,'" saw faint print images over or in place of or to right of the stimulus word in nearly all cases. She appears to have given herself an Aufgabe of this sort, just as Ev set himself for synonyms.

Visual-verbal imagery illustrated.

B.			
1861-62	Grant	1961	Visual of 1861-62 typewritten at top of page.
Y.			
culture	German	1521	Saw KULTUR against dark background
humble	meek	1099	Saw written The Terrible Meek.
T.			
gray	grey	2374	Saw it typed alongside.
R.			
comely	girl	597	Saw it written in book all together.
S.			
majestic	theatre	1047	Pronounced. Almost saw "theatre" printed. Saw "Majestic" capitalized.
clock	o'clock	885	Saw "o'" before "clock."
jeopardy	leopard	1070	Transferred enough letters to make "leopard" appear in place of "jeopardy."
low	bellow	877	Saw bellow" in print in place of "low."
punch	Judy	716	Faint print image a little to right (typical).

moist	moisture	865	Saw "ure" added, though in a way image appeared separate from original word.
By.			
braes	Scotch	2026	Tried to think of meaning and thought of "Scotch" visually.

S also has what seem to be entirely visual-motor images of words, images "projected into space" before her.

gem	stone	933	Pronounced "gem." Faint air image of "stone."

She says of these air images, "I don't see them exactly, but I know they are in a certain place, and that I am focussing my eyes on them."

Next to visual, the largest amount of concrete imagery or sensation reported is motor or kinaesthetic. To the reports that have already been cited in other connections, the following are added as being especially interesting or clear cut.

Y.			
briskly	quickly	488	Sense of motion, then "quickly."
streaming	good	1071	Pleasant image of a flowing down line. "Good" (perseveration) surprised.
jeopardy	danger	960	Swift, vague sensation of catching breath, as if a faint reflection of a dangerous experience, then the word.
vast	big	888	"Vast" seemed to swell till letters were giant ones, against bare cliff. Then the word.
H.			
briskly	walked	1074	Feeling of motion, arms, elbows, skirts. Some one on Engineering walk.
animated	expression	1376	Feeling of a face in motion. Not my face, anybody's.
B.			
briskly	trot	1515	Kinaesthetic sensation. The word. Then indistinct visual of horse.
R.			
carrot	top	654	Motor image of carrot before getting "top."
omnibuses	London	1272	Saw busses in motor way.

Auditory imagery was reported very seldom. The stimulus words[52] which it was thought might induce it were not very successful. The majority of the responses were verbal, most of them quite automatic or capable of being so interpreted. With *grate, wind, chink,* and *rippling* the associations were all auto-

[52] List of words: *rippling, hum, wind,* silvery, bell, clock, *murmur,* lapping, *chattered,* chink, bugle, jingle, grate, piping. The words that received the largest number of auditory responses are italicized. 'Clock' had no such responses, either in vocabulary or in imagery, and 'silvery' had one in vocabulary (silvery-voice) unaccompanied by an auditory image.

matic, though R and E did report auditory imagery with *rippling* (*—stream,—brook*). 78 of the words given in response, 117 responses, may safely be said to be automatically verbal of some sort. There were 53 reaction words with which sound might have been expected, but did not appear; as *murmur—bees, wind—howl, rippling—waves, lapping—plashing, jingle—jangle, piping—note.* There were only 17 reactions to these words that could possibly be classed as auditory—in the sense of accompaniment of word by auditory imagery. *Serene,* however, gave S verbal and musical imagery. Of the subjects, E had 7 auditory reactions, Y 5, and R, By, Ev, B, and H one each of which I could be sure. These results do not include the auditory factor that was probably present in the auditory-vocal-motor complex, in verbal imagery like that of H for example.

H.			
bugle	blow	1263	Thought of "Blow, bugle, blow."
S.			
serene	day	921	Song "This is the end of a perfect day" began to sing itself.
E.			
jingle	loathly	4034	(Complex train of thought, Spenser's "loathly lady.")
wind	trees	2390	Sound of wind in big pine woods. Visual of trees.
hum	bees	1218	Bees in alder tree, "just booming" in it. (Typical.)
Y.			
chattered	noise	1295	Picture of tree full of birds. Then big table at house.
B.			
chattered	squirrel	2059	Auditory image, then word, then visual image.
By.			
hum	bee	1323	"Bee" from sound of "hum." Then "Vergil." Said "bee" with "Vergil" in mind.
R.			
rippling	stream	979	Got sound of rippling and "stream" suggested itself.

Unanalyzable Mental Content.

The following records of unanalyzable mental processes fall into the two groups made by Messer and others,[53] of intellectual and affective attitudes; of feeling-toned[54] and purely intellectual

[53] Messer, Untersuchungen über das Denken, p. 184. Ach, Ueber die Willenstätigkeit und das Denken, p. 213.

[54] The word is here used in its more general and comprehensive sense.

thought. The feeling-toned I have not sub-divided; the intellectual fall into two main classes. (1) A complex matter is present as a single attitude or impression, a good deal, as Ach[55] says, in a nutshell; remembrance of instructions or of conditions of task, and in some cases meanings, seem to come under this head. These contents like some much simpler might be explained as residual or partially excited groups of processes. (2) There is a sense of relationship, of a thing belonging to the same group or having the same pattern as another, a consciousness of likeness or similarity.

Closely related to these are the processes that show the influence of an idea not present as a distinguishable element, the control of a "determining tendency."[56]

Feeling-toned.

Y.			
blue	red	899	Vivid picture of blue. Tension, word brought relief.
grim	sorry	....	Sense of harshness, then word.
H.			
frog	legs	329	A friend likes them. I don't. Feeling-toned.
logical	analysis	....	Cold bare feeling. Thought, what else is like that?
A.			
drab	dress	....	Immediate impression of something unpleasant. Notion of colored dress followed. Unpleasantness possibly due to symbolism.

Intellectual content.

(1) Complex matter appearing as single (simple) attitude or impression.

Partially excited imagery.

Y.			
medium	James	1455	Vague complex of spiritualistic practices. James' attitude toward mediums, then the word "James."
tapir	Beatrix	1347	"Animal" came first, then in "tumbled" the whole Beatrix incident (from a previous experiment).
equivalent	equi-valent	1163	Length made me pronounce to myself. Hurried flash of the Chemistry building and S. and a talk about different valences with S. a day or so ago.
braes	Scotland	787	Sense of cool wood with stream.

[55] Ach, Ueber die Willenstätigkeit und das Denken, p. 211.
[56] *Ibid.*, pp. 209, 228.

S.			
1861-62	Civil War	1463	As said "Civil War," distinctly conscious of some previous experiment. Felt self in Miss S.'s room, though no definite imagery.
remember	dust	1642	Thought "that" first, but it didn't seem worth saying.
R.			
florid	face	470	Thought "Florida," but wanted to say something sensible.
dyes	red	2003	Rejected "red" as a verbal. Saw dyes and finally said word. (This, the two preceding reactions, and Ev's "sesquipedalian" below show the presence of an attitude of mind, a self given Aufgabe.)
heterogeneous	homogeneous	2267	Several unformed words came up.
Ev.			
sesquipedalian	nothing	3941	First tried to remember what word meant. Felt would not be able to get synonym; all the time feeling for word that would correspond in some way. "Nothing" sort of statement of failure. (This introspection shows very well the difficulty of classification. The feeling for word that would correspond, if not that for a synonym, is of the nature of a feeling of relation, and is given again there.)
Murmur	sound	1322	Delayed by some poetical association.
golden	silver	1888	Bothered for a moment because didn't compare in form.
B.			
punch	bag	1087	Thought of "punch—", but "bag" came. Later visual of punch-bowl.
H.			
tide	time	1669	Feeling of darkness and line of poem I couldn't get, so said "time" instead. Now I know it was "Oh life's full bitter tide."
isobar	Isadore	1454	Thought first of word of three syllables ending in bar, a grand name. Then Mrs. ———'s name an easy substitute. Later "Conchabar."

Meanings.

Y.			
severe[57]	hard	3203	*Idea of sternness,* associated vaguely with middle-aged woman, then word, all at the same time.

[57] This meaning, and others in the section on meanings in concrete form, recall Ribot's statement: "We learn to understand a concept as we learn to walk, dance, fence, or play a musical instrument; it is a habit, i.e. an organized memory." (General Ideas, p. 131, quoted by Titchener, Experimental Psychology of the Thought Processes, pp. 200-201.)

A.			
florid	complection	1083	Repeated word. Knew quality of person. Thought of a cheek. Followed by articulatory tendency to say "complection."
grate	fire	997	Hesitation as to which of two meanings to take.
Ev.			
fly	bird	1944	Hesitation (think between insect and act), surprised at reaction.
dichotomy	broken	3554	Knew it was separateness or twoness, and "broken" came first.
turf	race	1632	Understood in sporting sense, but for minute no word.

(2) Relations.

Ev.			
sesquipedalian	nothing	3941	All the time feeling for a word that would correspond in some way.
distribute	spread	1859	Distinctly suggested supplies to the Belgians. Groped for word to express that kind of distribution.
R.			
wit	humor	1476	Vaguely conscious before "humor" came that "wit" was one of a pair. "And" had tendency to come.
Y.			
bliss	gay	783	As saying "gay" had a feeling that it did not fit "bliss."
over	behind	685	Sense of small word meaning direction. Then "behind' popped in.
also	then	1343	Feeling of little nondescript grammatical word.
B.			
equivalent	geometry	2385	Placed in mathematical group immediately. "Geometry" first to come.
S.			
animated	pop-gun	930	Felt it was crazy. Image of the thing followed.
Ev.			
prose	verse	1376	Slight dissatisfaction. Missed *and* or *poetry*.
treasure	trove	1773	A waiting for and recognition of "trove" as the right word.
Orpheus	Eurydice	1642	Distinct feeling, who is the other one? Couldn't tell if it was other person or other word.
grate	great	1453	I do not know. I do not think that I visualized it; the first idea that occurred to me was that it was a word of several meanings and I just gave one of the others.

Influence of the idea in mind.

E.			
26 broadens	road	1784	A broad white road, very dusty, fern and laurel along it, widens suddenly as it turns.

27 olivaceous	trees	5992	Saw dusty olive trees, yellowish in the sun, with dark olives on them, by a dusty road.
28 culture	vineyards	2189	A very dusty, slowly sloping hill with grape vines, very heavy with dark blue grapes, on its terraces. I had a vague impression of lake water, blue and shining hot, between me and it.

Influence of Kind of Word.

Very little influence upon imagery of the kind of word[56] given can be detected. The abstract terms (logical, due) do not as a rule produce imagery, and when they do it is only with the more imaginal subjects—E, Y, and H. E succeeds in interpreting most of them as connotative. For example:

wit	man	1453	Picture of a man laughing discreetly.
yes	eyes	4220	Girl looking up at man, telling him she would marry him.

Abstract words have a tendency, noticeable particularly with Ev, to produce meaning content in more or less unanalyzable form. In the case of "dichotomy" he "knew it was separateness or twoness, and 'broken' came first." Words of the sensuous class (hum, chill), though they have a tendency to produce imagery, have no marked tendency to produce it in kind, as was seen in the discussion of the auditory group. The objective (frog, bell) and connotative (treasure, vagrant) groups get a certain amount of imagery; the records of those subjects who have very little imagery would lead one to think that they are the most productive of imagery. The kind of word, however, does have a marked tendency to produce the same kind in reaction, the per cents varying from 84 with Ev to 41 with E; and words commonly produce others from the same general category. An interesting illustration of this last point came up in connection with experiment V of the preliminary tests, the making of word lists,—for instance, writing as many rhymes as possible in a minute to *speak*. The subjects were asked to report all the rejections, and one of them said that he had been a reporter and knew a great many words which he would not like

[56] Description of association test. Chap. I, pp. 6, 7.

to report to a lady and that he was afraid they would come up. At the conclusion of the experiment he reported that he had not been troubled by this vocabulary. It had not fitted the situation and had not come up.

SUMMARY.

The times, beyond showing that quick word to word reactions might be expected from Y and S and slow from B, Ev, and E, show a marked tendency of the presence of concrete imagery to retard the time, except in the case of Y, and to retard it more for the imaginal types of subjects than for the verbal, with the same exception of Y.

Concrete imagery occurs in considerable quantity with several of the subjects, with the imaginal types but not with all of them. 56% of Y's reactions and 97% of E's were accompanied or preceded by concrete imagery. It seems clear that concrete imagery having to do with either stimulus or reaction word occurred before the reaction word, and that such occurrence is to be associated with the visualizing, or other imagizing habit, of Y, E, H, and B, in connection with words, possibly in connection with reading, though the isolated word is, of course, quite different from words in combination, and much more emphatic. Mental content impossible of analysis by the subject appears frequently, is characteristic of some subjects, notably Ev, and must be taken account of in diagnosis. The difficulty here on the part of the subjects was to distinguish between what came before and what came after the speaking of the reaction word. Imagery developed very rapidly in many cases, especially during introspection.

CHAPTER IV

Individual Diagnosis Records.

The diagnosis sheets that follow summarize the information yielded as to the individual subjects, by the experiments of the two preceding chapters. I have added to this accounts of the speech and writing habits and other pertinent characteristics of the subjects, drawn from my personal knowledge of them, and a few reports of imagery from the experiments of Chapter V.

Experiments Summarized.

Preliminary Tests.

I. Reading of descriptive passages.

II. Spelling backwards, and pronouncing from words spelled backwards.

III. Groups of symbols.

IV. Words that sound alike but are spelled differently.

V. Lists of words: rhyming to test auditory-vocal-motor, with the same ending to test visual.

VI. Words that are spelled alike but sound differently.

VII. Picture postcards.

The Free Word Association Test.

A.

(Fernald: Auditory-vocal-motor.)

III. First group for 6 items, medium for 9. Method, largely visual motor.

V. a. Third group.

b. Second group, high. Visual-motor supplemented by articulatory. Perhaps more visual than he thinks.

c. Second group.

VII. Low rank. Poorer record for 10″ than for 2″. Verbal and visual, probably largely visual-motor. Many errors, especially in colors, due to association and naming and probably to lack of color imagery. Reports often very full, but full of errors. Reports learning by eye and head movements. Noticeably verbal, but not so exclusively a naming process as he supposed. Tendency to use after images to lengthen time (see B). Delayed recall seems to be from a visual image. Least visual subject.

Association Test. Average time 1.589″. General verbal 88%. Phrases 59, some logical and predicative reactions. (Verbal.) Noticeable lack of concrete imagery. None preceding. Imagery increases time 37%. Some verbal rivalry, more automatic reactions tend to come. Reversed verbal lengthens time. Some unanalyzable content.

Summary.

III-V. Visual-motor supplemented by articulatory. Fair record and fairly flexible.

VII. Low rank. Verbal, visual, visual-motor. Poor color imagery. Naming, associations. Recall from sort of visual image, nothing vivid about it.

Association Test. 7th in reaction time. Verbal, probably internal and automatic. Little concrete. Unanalyzable. Fairly flexible.

An instructor in psychology. The introspections in general are meagre. The subject does not find imagery to report.

B.

I. Visual, vague, unrelated. Kinaesthetic reported for smell. Very fleeting auditory. Organic and kinaesthetic sensations strong. Verbal memory good. Some unanalyzable impressions. Fairly flexible, slow.

II. a. Very slow. Vocal-motor and articulatory method, spells forward several times. Visual practically no use.

b. Time medium. Vocal-motor method. "Reversed in some way not visual."

III. For 6 items heads list, for 9 items second. Articulatory and visual method with associations.

IV. Heads list. Auditory-vocal-motor method, visual as check.

V. a. Third group, at foot. Purely articulatory method. Nonsense words inhibited. Slow.

b. Third group, very slow. Articulatory rather than rhyming. Unable to use visual.

c. Third group. Lack of flexibility.

VI. Heads list. Articulatory, and probably motor imagery. No visual, no auditory reported.

VII. Lowest rank. Visual, motor, verbal, meanings. Sees colors brighter than on card. Gets very little color from 2″ exposure. Probable weakness in color imagery and holding visual factors grouped. Visual imagery in recall neither distinct nor accurate. Attention to balance, and tendency to draw, probably motor. Gets diagram in 2″. Uses phrases rather than words in learning. Verbal method seems to help. Does not know how her delayed recalls come, has visual image in mind during description, built up, more a checking process than a remembered whole.

Association Test. Average time 2.265″. General verbal 84%. Verbal phrases 60, a few logical and predicative reactions. Some visual-verbal. Some kinaesthetic, at least one auditory. Concrete imagery 31%, some preceding—images related to reaction word, causes delay of 62%. Verbal associations tend to overcome visual. Some verbal rivalry, less automatic tend to come. Great many reversed verbal, time lengthened greatly. Meanings in indistinct concrete imagery. Some unanalyzable impressions.

Summary.

I. Visual vague, auditory fleeting, kinaesthetic and organic strong, some unanalyzable. Slow.

II-VI. Low record except for VI. Vocal-motor, articulatory, schematic relation. Visual used only as check. Inflexible.

VII. Lowest rank. Method largely motor and verbal, a little visual-concrete. Can build up visual as a check. Gets diagram very quickly, color slowly. Phrases rather than words.

Association Test. Very slow. Very verbal. Verbal overcomes visual-concrete. Good deal concrete which delays time 62%. Time greatly lengthened for reversed verbal. Some unanalyzable content. Inflexible. Internal verbal.

Group IV. a. The siren. Sentence followed by very fair small drawing of a siren—the side that had not been exposed to her! Her record for IV was very verbal.

Graduate student in psychology. Has worked in a number of experiments. Not musical. Draws. Rather slow of speech and movement. Not ready as speaker or writer.

By.

I. Visual lacking or dim except when special need. Some lack of tendency to organic reaction. Considerable effect of rhythm. Verbal memory not good. Gets significance rather than words. Says musical memory is vocal-motor. Flexible.

II. a. High record in time and correctness. Visual.

b. High record for both times, longer for 2 letters per second. Visual of word as group of letters. Guesses.

III. Very high record for both sets. Articulatory, probably mixed with visual schematic.

IV. First group. Used sense combinations and deduced in learning, checked by visual. More visual in recall.

V. a. Second group. Automatic verbal.

b. First group. Highest. Vocal-motor, and visual for check.

c. First group. Flexible.

VI. No record.

VII. Highest record for 10″ period. Very great improvement from 2″ to 10″. Visual, some verbal. Attention to color and light. Very distinct and accurate visual. Always gets lines before color, probably eye-motor. Recalls visual. Images of delayed recall seem firmer and clearer than of immediate.

Association Test. Average time 1.502″. General verbal reaction 88%. Phrases 70. Concrete imagery 15%, a number preceding, many connected with the reaction word;

increases time 33.5%. Verbal association will overcome verbal-concrete. Visual-verbal occasionally. Some verbal rivalry, more automatic reactions tend to come. Some auditory.

Summary.

I. Visual concrete lacking except when needed. Directed by words. Gets significance rather than words. Strong rhythm and vocal-motor. Flexible.

II-VI. Very high record for visual-verbal. Second group for vocal-motor. Flexible.

VII. Highest record. Visual very distinct and accurate. Eye-motor. Considerable verbal.

Association Test. Highest verbal record. Quick reaction time. Some visual-verbal. Some concrete imagery, increasing time a good deal. Automatic verbal marked. Flexible type.

Has been a newspaper reporter, is at present an instructor in rhetoric. Writes constantly both prose and verse. Very critical turn of mind. Musical. Very quick and observant. A lively and disputatious talker, and a very ready writer.

E.

I. Concrete imagery emphasized by practice. Can use a great deal of visual without noticing confusion, but is probably confused. Smell. Auditory strong. Organic almost lacking. Rhythm memory marked. Many "feelings" (emotion-toned). Verbal memory not very good. Inflexible, visual-concrete. Very slow.

II. a. Slowest time. Poor speller. Visual, confused, some vocal-motor.

b. Visual method gives quick times for short words, long times for long words. 2 letters per second, time improved greatly, used auditory aid.

III. Medium group for 6 items. Low for 9. Articulatory and visual.

IV. (Visual). Third group. Reports a good deal of visual. Visual-concrete and auditory.

V. a Third group. Great deal of visual-concrete, lengthens time. Probable confusion.
  b. Third group. Ability to visualize interfered with rhyming habit.
  c. Third group. Lack of flexibility.

VI. Fair. Mixed method. Auditory. Visual, both concrete and verbal.

VII. High record, slow. Reports no verbal. Attention to color, pretty distinct but not always right. Picture not especially distinct or accurate. Vivified cards (motor). Recalls as if had drawn. Very great improvement from 2 to 10″. Not flexible.

Association Test. Average time 3.356. General verbal 39%. Verbal phrases 14. Literary vocabulary noticeable. Concrete imagery 97%, 50 cases preceding, delayed time 42%. Most auditory. Time shorter for reversed reactions. Many meanings in concrete form. Imagery complex.

Summary.

I. Concrete imagery emphasized by practice, especially visual and auditory. Rhythm memory marked. Much feeling-toned. Very slow. Considerable confusion. Inflexible.

II-VI. Visual method very slow, improved by auditory-vocal-motor aid. Very low record. Visual-concrete distraction. Lack of flexibility.

VII. High record, slow. Visual and motor. Much color. Recalls visual, no verbal reported. Not flexible.

Association Test. Slowest time. Word to word apparently automatic accompanied by concrete imagery. Auditory. Many meanings in concrete form. Inflexible.

2b. of Group III affords very interesting illustration of the auditory and rhythmic working of E.'s mind. Card shown was of ruins at Luxor, a gray print. At about 8″ subject began to make marks. / ⏑ ⏑ / ⏑ ⏑ / ⏑ (slow) / She looked at the statue and "thought it had an eternal expression. Then I marked off the meter, and my mind made the sentence. *It made me think of the* *meter of a song.* The meter sounded like gray tones, like the stone in the picture. It came in beats, I heard it. The heavy beats were *b* below middle *c* I think, the others a third lower."

Graduate student in rhetoric. A writer of delicate and fanciful verse. A very reluctant writer of prose. A very slow and rambling talker, but fond of talking. Probably some of the slowness due to self criticism, and some to nervousness. Has deliberately trained her visual and other concrete imagery as a preparation for the writing of poetry of a decidedly "imagist" cast.

Ev.

I. Visual very fleeting, none from stanza. Draws from written descriptions. Got significance rather than images. Tactual, organic and rhythm strong. Good verbal memory for prose. Much unanalyzable.

II. a. Time slow, low per cent of correctness both oral and written, worse for written. Method phonetic. Reports a feeeling that the process is wrong.

b. Very slow time. Vocal-motor reversal. Great deal of guessing from first part of word.

III. Medium group for 6 items, lowest for 9. Method articulatory and visual. Low record possibly due to slowness.

IV. "Couldn't do it. Meanings funny. No visual."

V. a. First group. Purely rhyming process.

b. First group. Mixed, auditory-vocal-motor with visual as test.

c. First group. Mixed method, flexible.

VI. Lowest record taken. Apparently articulatory.

VII. Low rank. Verbal for 10″. Some visual. Attention to color and light. Practically no errors. Gets localization by light and shade. Tendency to draw. Delayed recalls visual, much color. Finds colors brighter than he remembered them. Named more for identification than for memory. Makes good record for the short exposures.

Association Test. Average time 1.866″. General verbal 82%. Verbal phrases 23, synonyms 27. Consciousness of meaning. Concrete imagery 5%, lengthens time 25%. Concrete precedes in a few cases. Good deal of verbal rivalry, more automatic tends to come. Some reversed verbal, time lengthened. Meanings and relations in apparently imageless form.

Summary.

I. Significance rather than words or definite images. Visual very fleeting. Verbal memory good. Great deal unanalyzable.

II-VI. Very slow with II. High rank in V. Vocal-motor and articulatory. Mixed with visual for test in the visual tests. Visual not very successful. Much guessing. Flexible.

VII. Low rank. Very dependent on associations and relations. Attention to color and light. Accurate. Visual syncopated. A little verbal.

Association Test. Slow time, fairly verbal, verbal not very automatic. Meanings. Little concrete imagery. Much unanalyzable. Flexible.

4 of Group III. Talked, not from a picture, but from some sort of mental record of the things in it. (The circumstances here are different from those of VII of Group I where the subject was deliberately memorizing.) Occasionally something comes back that I don't remember noticing—comes visually—but surely 95% of what comes I have consciously attended to. The record isn't in words usually, though it may contain words. Have a chain of ideas, images, symbols, words, all sorts of things, quite constantly. Images tend to come when usual process is not adequate. Wanted the right word for color of woman's gown, for instance, and got visual image of it.

An instructor in rhetoric, a trained artist. Very keen mind with a speculative and humorous bent. Writes a good deal and very well. Very deliberate and slow of speech as of other movements, talks well when he talks which apparently is not often. Vocalizes a good deal between words, especially when thinking.

H.

I. Visual-concrete, vivid, colorful, of movement. Gets full, unified and complete picture. Gets suggestions from word rather than direction. Auditory. Many feelings and impressions. Good memory of rhythm. Organic strong. Verbal memory of stanza very good.

II. a. Time record like that of visuals. Probably vocal-motor, a motor reversal, "lost if you stop."

c. Slow record for 1 letter per second, still slower for 2 letters per second. Wrong guesses from portion of words. Vocal-motor.

III. Third group. Articulatory and visual. Method improved for 9 items. Uses meaningful combinations.

IV. Last. Learned by "saying." Much confused.

V. a. Second group. Large auditory element. Many associations.

b. Second group. Visual method supplemented by articulatory.

c. Second group.

VI. No record.

VII. Low rank. Verbal for 10″. No improvement from 2 to 10″. Visual, motor. Much preoccupied with color. Recalls color that was not there. Due to vivifying picture, probably motor. Many feelings and impressions. Critical. Recalls from a picture, Detail full, not always accurate, influenced by associations. Details separated if she names. Naming confusing.

Association Test. Average time 1.558″. General verbal 82%. Verbal phrases 63. High record for literary context and vocabulary. Concrete imagery 36%, delayed time 45%. Good deal of verbal rivalry, more automatic reactions come. Reversed verbal lengthens time. Much unanalyzable.

Summary.

I. Visual-concrete, vivid unified picture, suggested rather than directed by words. Auditory. Very strong organic and rhythmic. Very good verbal memory.

II-VI. Method auditory-vocal-motor and articulatory. Meanings in more or less imaginal form. Many associations.

VII. Low rank. Use of words in learning breaks up image. Recalls as pictures, influenced by association. Much unanalyzable, feeling-toned.

Association Test. Time medium. Word to word association strong, probably automatic verbal. Good deal concrete, delayed time a good deal. Much unanalyzable. Probably inflexible.

An English instructor and a graduate student in rhetoric. A writer of fine and thoughtful verse. Artistic, enthusiastic. Sometimes talkative and quick of speech, inclined to self criticism, however, so that much of her speech, especially thoughtful speech, is deliberate, even stumbling.

R.

I. Visual schematic. No visual for stanza. Color present. Smell, auditory, tactual, organic, present in unusual strength. Body motor or kinaesthetic habitual. Verbal memory and rhythm not good.

II. a. Slow time. Perfectly correct. Method vocal-motor, probably usually articulatory.

b. Longest time. Learned to spell words backward (lip motor). Long time due to disinclination to trouble of reversing.

III. Medium group for 6 items, about the same for 9 items. Articulatory and non-visual relationships.

IV. Third group. Purely articulatory method. Poor.

V. a. Second group. Some visual concrete imagery at first. Some visual-verbal.

b. First group, high. Auditory-vocal-motor and visual mixed.

c. Second group.

VI. No record.

VII. Good record. Schematic visual and motor. Verbal. Increase in per cent of details with increase of time, more visual, more verbal. Not interested in color. Got it in a black and white print. Colors mixed him up. Accuracy good. Great deal of motor, eye motor for position. Recall through motor, visual-concrete, or verbal phrase. Flexible.

Association Test. Average time 1.462″. General verbal 74%. Phrases 46. Presence of literary vocabulary and phrase marked. Concrete imagery 22%, some preceding the reaction word; lengthens time 27%. A little visual-verbal. Kinaesthetic and auditory. Considerable verbal rivalry, more automatic reactions come. Much reversed verbal, time considerably longer. Some unanalyzable. Flexible.

Summary.

I. Visual where it occurs schematic; smell, auditory, organic, motor, a good deal.

II-VI. Articulatory, and motor relations. Difficulty in reversing. Auditory-vocal-motor and visual method gives better results than auditory-vocal-motor. Fairly flexible.

VII. Good record. Schematic, visual and motor. Improves with time. Color confused. Good deal of eye motor. Delayed recall visual, motor, or phrase. Noticeably verbal. Flexible.

Association Test. Average time third. Quite verbal, probably both automatic and internal verbal. A little visual-verbal. Considerable concrete imagery, motor and visual. Good deal of unanalyzable. Very flexible.

Graduate student, psychology and medicine. Likes to talk, but dislikes very much to write. Musical, whistles while writing, not a distraction.

Rg.

I. Visual-concrete, clear, slow stages for movement. Rhythm. Gets visual complexes very much syncopated, almost imageless. Verbal memory fair. Feeling-toned impressions. Somewhat inflexible.

II. a. Time medium, smallest per cent right for oral. Great improvement for written. Method mixed, visual and vocal-motor. Written "much harder," time doubled.

b. Slow. Had to have several spellings. Visual, guessed.

III. First group for six items. Third for 9 items. Articulatory, some visual. Meaningful combinations.

IV. Second group. Used meanings and some visual. Method improved.

V. a. Second group, lowest. Not a rhyming process. Based on auditory and visual similarity of form.

b. Second group. Probably auditory-vocal-motor and visual form.

c. Third group. Mostly auditory-vocal-motor. Not flexible.

VI. No record.

VII. Fair record. Visual, some verbal especially in 10″. Attention to color, but often wrong and mixed up. Not accurate. Recalls rather hazily as pictures. Gets color tone before individual figures come. Pictures much changed. For 2″ saw pictures as a whole in recollection, for 10″ tried to burden mind with details, lost single impression. Verbal seems to be a poor method.

Summary.

I. Visual-concrete clear. Tendency to much syncopated visual complexes. Rhythm strong. Somewhat inflexible.

II-VI. Mixed method, visual and auditory-vocal-motor, the latter not a rhyming process. Not flexible.

VII. Fair record. Visual, some verbal, means confusion. Color often wrong. Her visual not very successful. Cannot handle much detail at a time. Little relation between visual and verbal. Not flexible.

a. of Group V. The flower jug. First sensations of color, the metallic lustre and the background, then the shape of the thing. The Chinese bag. Feeling for the texture of the thing as well as for its color.

A graduate student in chemistry. A very reluctant writer. Not talkative except under favorable circumstances. Musical.

S.

I. Visual-concrete, occasionally definite and fragmentary, more often fleeting and general, nothing fixed about it. Some auditory and organic. "Feelings," especially of locality. Verbal memory not very good. Much unanalyzable. Flexible.

II. a. Good record. Mixed visualizing and pronouncing.
b. Good record. Time rather better for 2 letters per second. Guesses. Reports still more mixed method, auditory-vocal-motor and visual.

III. Second group. Visual-motor, and associations.

IV. "Made sense," deduced. Some help from visual.

V. a. Second group. Mixed method.
b. Third group, lowest. Rhyming method, interrupted by slow visual.
c. Third group.

VI. Auditory imagery clearly present.

VII. Very low record. Visual, associations, verbal for 10″. Low rank for 10″ due to distracting images and ideas. Color a secondary consideration, probably a weak image. Visual neither distinct nor accurate, disordered. Locality sensations probably visual-motor. Cards come back vaguely as pictures. Associations interfere with accuracy.

Association test. Average time 1.182″. General verbal 84%. Phrases 46. Stimulus from word form, through both appearance and pronunciation. High record for literary context. Presence of literary vocabulary and phrase marked. Imagery largely visual-verbal. Reversed verbal mostly visual, time about the same. Much unanalyzable. A little concrete imagery, increased time 24%.

Summary.

I. Visual-concrete definite and fragmentary, or fleeting and general. Some auditory and organic. Some unanalyzable.

II-VI. Mixed method, auditory-vocal-motor and visual, the latter largely visual-motor. Tendency to deduce and make sense. Not flexible.

VII. Relative standing very low, dependent upon associations which interfere with accuracy. Recall, vague pictures.

Association test. Quickest time. Visual-verbal largely. Much unanalyzable. Apparently flexible.

English instructor and graduate student in rhetoric. Not much of a talker and rather slow of speech. Use of words in writing unusually exact and discriminating. Not musical. Philosophical bent.

Sc.

I. Visual clear and unified. Organic not strong. Feeling of position and attitude strong. Verbal memory good. Some unanalyzable. Flexible.

II. a. Highest time record. Record for correctness, oral low, written perfect. Method visual and vocal-motor, visual not very trustworthy.

b. Time somewhat longer for 2 letters per second. Very good guesser. Method, visual and auditory-vocal-motor. Builds the word up out in front, sees it but not distinctly.

III. For 6 items second group, for 9 items highest. Articulatory and visual. Perseveration marked in recall.

IV. Second group. Articulatory and visual.

V. a. First group. Rhyming process. Some visual-verbal appearing.

b. Second group, high. Probably visual supplemented by articulatory.

c. First group. Very flexible.

VI. Tried to remember pronunciation by remembering meanings. Probably auditory-vocal-motor.

VII. High rank. Visual, and verbal in 10″ exposure. Colors more vivid in recall than on cards. Seems to lack names for colors. Claims good color imagery. Accounts quite accurate and definite. Marked tendency to draw. Recalls come back definitely in visual imagery, much detail. Thinks names and visual images extremely closely connected. Puts down what he "remembers," rather than what he sees.

Summary.

I. Visual clear and unified. Motor strong. Good verbal memory. Some unanalyzable. Flexible.

II-VI. High record. Auditory-vocal-motor, visual-motor and articulatory. Much guessing. Very flexible.

VII. High rank. Visual and some verbal. Coloros very vivid, not connected with words. Recalls, visual and detailed. Thinks names and visual images closely connected. Flexible.

An instructor in rhetoric. Talks well, rather rapidly and a good deal. Writes easily and a good deal. Strong sense of humor. Uses a great many gestures.

T.

I. Visual-concrete clear, complex and unified. Suggested rather than directed by words. Does not get significance quickly from words. Good visual memory. Auditory. Some organic. Probably motor. Not very flexible.

II. a. Good record in time and high correctness for oral. Written not so good, loses in both.

b. Good record. Time longer for 2 letters per second. Visual.

III. Second group for 6 items, higher for 9. Method articulatory and visual-motor, improves by visual relationships.

IV. Second group. Some visual imagery, method becoming more visual. Use of meanings.

V. a. Third group. Visual imagery with auditory-vocal-motor. Slow, unused to rhyming.

b. Second group. Visual supplemented by articulatory.

c. Second group.

VI. Auditory, aided by articulatory and some visual-concrete imagery.

VII. Fair record. Visual, and probably motor. Makes her improvement between 2 and 4". Remembers colors very accurately. Record fairly accurate, not very full. Recalls come back as pictures. Very few errors. No verbal imagery recorded.

Association Test. Average time 1.564". General verbal 90%. Verbal phrases 15. 62 reactions apparently due to influence of visual form of stimulus word. Concrete imagery 6.3%. A little preceding. Imagery lengthens time 43%. Some verbal rivalry, more automatic tend to come. Some visual-verbal. Some reversed verbal, time not lengthened.

Summary.

I. Visual-concrete clear and unified. Suggested by words rather than directed. Probably motor. Not very flexible.

II.-VI. High record for visual processes. Auditory-vocal-motor slow, supplemented by articulatory. Shows greater flexibility here.

VII. Fair rank. Visual. Accurate color memory. Reports not very full. No verbal reported. Recalls as pictures. Probably some loss in accuracy by association.

Association Test. Medium time. Word to word association strong. Probably automatic verbal. Very little concrete imagery. Some reversed verbal, time not lengthened. Imagery lengthened time 43%.

a. of Group IV. The flower jug. Complex matter present in mind, feeling-toned. Recall of moist rather heavy air of a basement flower shop where it was bought. Earlier than recall of buying, saw the vase on a bookcase at home.

Incidental introspections from T bear out the conviction that her thought is essentially wordless when the motive of direct communication is absent. One day after working on the experiment, she said that while a group of us were talking she saw out of the window three sophomores in a row go by, against the background of the Law Building, and was conscious of the odd and gay effect of the three red sophomore caps, without, she was certain, the presence of any verbal element until she undertook to tell me about the experience, when the words came quite automatically. At another time she said, "Look at that awful yellow coat! Now I didn't have any difficulty saying that sentence. But if I had been alone, hadn't been trying to express myself to you, there wouldn't have been any sentence in my mind, or any words probably, just an idea."

A zoölogist. Writes a little, scientific papers and reports. Not talkative. Rather slow and deliberate of speech, but of enthusiastic temperament. No musical ear.

Ty.

I. Visual-concrete when present clear, slow stages for movement. Attention to words. Smell, organic, and auditory present. Feeling of position and attitude strong. Complex and feeling-toned unanalyzable impressions. Verbal memory very good.

II. a. Very high record in time and correctness. Visual.
b. Highest time record. Shorter for 2 letters per second. Visual and auditory-vocal-motor mixed. Guesses.

III. First group for 6 items, highest record for 9. Articulatory, schematic relations, probably visual.

IV. Second group. Some visual, method not systematic.

V. a. First group. Auditory-vocal-motor, a little visual-concrete.
b. First group. Auditory-vocal-motor and visual mixed. Visual reported most important.
c. Third group. Possibly a visual preoccupation. Lack of discrimination.

VI. No record.

VII. High rank. Practically no improvement from 2 to 10″. Visual, visual-motor, some verbal. Attention to color, to light and shade. Vivid colored imagery, brightnesses more likely to be right. Accounts quite distinct and accurate. Marked tendency to draw. Many feelings and impressions. Delayed recall, visual and some phrases. Images of delayed seem firmer and clearer than those of immediate recall. Influenced by associations.

Summary.

I. Visual-concrete clear when present. Attention on words. Motor strong. Verbal memory good. Much unanalyzable.

II-VI. Very high record except for V.c. Method visual or auditory-vocal-motor and visual mixed.

VII. High record. Visual method. Distinct and accurate. Attention to color and light. Some phrases in recall of cards. Tendency to idealize. Much unanalyzable. Allows herself to be directed by words, but takes only suggestions from visual-concrete stimulus. Verbal probably mostly automatic.

A senior woman with decided literary talent, for both prose and verse. Musical and artistic. A lively talker and an enthusiastic writer. Tendency to Kundgabe error. Instead of describing her thoughts she expressed them, as it was the constant effort of her life to do. Especially noticeable and troublesome in the last set of tests.

Y.

I. Visual-concrete, definite, vivid, colored. Mainly concrete from stanza. Words unnoticed but directing. No rhythm. Probably faint auditory. Organic. Verbal memory fair. Some unanalyzable impressions, not feeling-toned. Inflexible, visual-concrete.

II. a. Slow. Mixed method, emphasis on visual but image a general one. Poor speller.

b. Slow for 1 letter per second, much quicker for 2. Cumbrous visual method of reversal, worked so badly for 2 letters per second that she guessed.

III. Very little success. Method articulatory and visual.

IV. No record.

V. a. Third group. Attention distracted by visual-concrete.

b. Third group. Auditory, tested by visual. Apparent lack of vocal-motor complex.

c. Third group. Inflexible.

VI. First group. Auditory and visual-concrete principally.

VII. High rank. Little change from 2 to 10″. Visual. Very definite and accurate. Practically no verbal reported unless planning written expression. Thinks verbal does not help learning. Recalls came as pictures, "Saw the edges of the card." Images of delayed recall seem firmer and clearer than they were in the immediate. "I see perfectly." Tendency to idealize.

Association Test. Average time 1.205″. General verbal 65%. Phrases 14. Very little indication of literary context or phrase. Concrete imagery 56%, many preceding; concrete delayed time only 4%. Rivalry of concrete images. A little visual-verbal. Good deal kinaesthetic and auditory. Reversed verbal time about the same or less. Many meanings in concrete form. Much unanalyzable.

Summary.

I. Visual-concrete, definite, colored, unified. Words unnoticed but directing. Auditory but no rhythm.

II-VI. Cumbrous visual methods. Attention distracted by visual-concrete. Auditory, but apparent lack of vocal-motor.

VII. High rank. Visual. Little verbal imagery. Recalls card as such. Tendency to idealize.

Association Test. Very quick time. Very little delayed by concrete imagery. Reaction words related to imagery rather than to stimulus word. Some kinaesthetic and auditory. Some unanalyzable. Images seem to be simple, many of them partaking of the nature of synecdoche, a part representing the whole.

An English instructor, a graduate student in rhetoric. Charming and vivacious talker and story teller, but with a curious drawling vocalization between words, particularly noticeable when she is thinking as she talks. A very good debater but a slow and laborious writer. Not musical.

Y's quick time for the association test plus her lack of verbal record earlier and her non-automatic verbal record here may be explained by the extremely close relation both between images and words and between words and images wherever words are in evidence. In I, the words served simply to direct imagery; they did not anywhere seem to be much present as imagery—they are automatic motor reactions. A similar tendency though not nearly so marked is observed in S, Ev, By, and R, none of them so imaginal as Y. S and Ev have rather suppressed imagery and a good deal of unanalyzable content. By and R are more concerned with word to word associations, which are very weak for Y. All but Ev have very quick reaction times for this test, and Ev's reactions everywhere are slow. There is a group of subjects who have well developed associations between images, and well developed associations between words, without apparently much flexibility in passing from one to the other; most noticeable of these, perhaps, are T and Rg. H probably belongs to this class. but pays a good deal of attention to the careful fitting of words to imagery—a slow process for her, probably of late development. E is somewhat similar, though with an engrossing interest in the imagery. Quick and automatic word associations characterize R and By, and probably, though they have no association test record, Sc and Ty. The last two have a great deal of imagery, approaching Y in that respect, and have certainly, like her, very close word-image-word relations. Their times in all tests are extremely quick. B has very verbal reactions of an automatic character, though very slow. She has a good deal of concrete imagery called up by words, but apparently the slowest reaction from image to word of any of the subjects.

The following scheme, with the most imaginal at the left and the most verbal at the right, gives as much of a grouping, probably, as can safely be made.

E	Rg		Sc		S	A
Y	T		Ty		Ev	B
		H		By		R

Although it is true that types cannot be grouped except in the most general way, I think the diagnosis records show that for each individual a *habit* in the use of imagery does become evident, modified, naturally, by the nature of the different tasks, but showing, after all, pretty constant elements and combinations. I am inclined to think that Miss Fernald makes too much of the differences in imagery for different tasks; there is, in general, a pretty well defined complex of tendencies. Her grouping of flexible and inflxible, as between verbal and concrete imagery, seems to me to be a useful one. The more flexible of my subjects are S, Ev, R, and By, with an emphasis on verbal, and Y, and probably Sc and Ty, with an emphasis on concrete imagery; the less flexible are A and B, with an emphasis on verbal, and H, T, Rg, and F, with an emphasis on concrete imagery.

CHAPTER V

Experiments Dealing with Verbal Expression and with the Mental Processes Preceding It.

Description of the Experiments.

The experiments of Groups III and IV were planned to provide material for the examination of a subject's speech and writing in relation to his imagery-complex; and also of his mental processes from the arousal of an idea to its expression in definite verbal form, oral or written, more especially of the amount and character of the verbal imagery present.

In Group III the picture postals were exposed on gray cards by means of an apparatus worked by cords, as simple and noiseless as possible. The subject's chair was set about six feet from the card. He was allowed to modify the distance slightly if he just naturally moved his chair. All the experiments described in this chapter were carried on in a neutral tinted room of many windows, designed especially for the control of lighting conditions. The work was done during the clear daylight hours of the winter and early spring of 1916, the subjects coming at approximately the same hours each day. Nine subjects worked on these final tests. A stop-watch was used instead of a chronoscope because it was felt to be less obtrusive, and because, since the experiment was concerned with such general conditions, the differences in time shown by the watch seemed sufficiently exact. Other experiments should be made, dealing with more definite and minute portions of the process, and accompanied by a more exact time record.

In the first series of Group III eight picture postcards, three in black and white and five colored, were used. This series was considered preliminary, to accustom the subjects to the apparatus and the general nature of the task, and the investigator to the characteristic variations and peculiarities in response of the subject. The directions were as follows: "After I say *Ready* a picture postcard will be exposed to view. Say the first thing that comes into your head to say about it." The cards were exposed at first for a definite period, say 4″, but as the covering of the card seemed to serve as a distinct stimulus to speech-reaction—a sort of precipitating factor—hurrying it and confusing the subject, they were later left exposed until the subject had spoken, really a much more natural situation.

If the responses came in single words and short descriptive phrases, as they commonly did, the direction to respond with a complete statement was given with the fourth or fifth card. The time elapsing before speech was taken with the stop-watch, and occasionally the time occupied in saying the phrase or sentence. Introspections were asked for, covering the time from *Ready* to the beginning of speech, and further if anything significant occurred.

Series 2 consisted of ten cards in groups of five each, chosen so that the cards of the two groups were as nearly similar as possible in interest, and in type and complexity of subject. For the first five (2 a) the subject was asked to respond orally with the first complete statement, impression, opinion or the like, that came to mind, the word judgment being deliberately avoided; for the second five (2 b) he was asked to turn to the table as soon as he could write a complete statement and write it out. The expression of the sentence in both cases was followed immediately by a written introspection covering the whole process, and times were taken at significant points.

Series 3 was made up of four colored cards (Tuck's Oilette Series), which were shown with the following times and directions:

1. Observe carefully. (Card exposed 5″.) Write a brief description of the scene, such as might occur in a theme or a letter.

2. Observe with a view to writing a brief descriptive theme. (Card exposed 5″.) Write.

3. Observe carefully. (Card exposed for 10″.) Describe what is to you the most interesting thing about this picture.

4. Observe, in preparation to giving your impression afterward in artistic written form. (Card exposed 10″.) Write.

The time spent in writing was taken with the stop-watch.

In series 4, the cards were similar to those of 3, the directions were modified for expression in speech, and the description of the cards was oral. Times were noted by the investigator, and a shorthand account was taken by a stenographer in the next room (her presence unknown to the subject), so that the times and character of oral expression might be compared with those of written expression in series 3.

In Group IV stimulus objects were exposed by turning on a light over a table in the next room, a darkroom, the room in which the subject sat being in darkness except for a little light which entered through one partly opened shutter. (A desk light was used at first but was not very satisfactory.) As the subject faced this light until he turned his head at the signal *Ready,* his eyes did not become especially adapted to the darkness. Four objects (a) were exposed, for 5″ each, the exposure followed by a written description—a reproduction in words of the object or of the subject's impression of it,—preferably in a single sentence though it might be longer. Four objects (b) were then exposed with the direction that the subject was to react with the first sentence that occurred to him. Among the objects shown were two complicated pieces of apparatus from the psychological laboratory, an 'antique' flower jug, carrots, an embroidered bag of Chinese workmanship, an ivory fan, two comical white china figures, a book with a brilliant red cover ornamented with gilt, and a shallow vase with a thin-stemmed pedestal. I feel that more could profitably be done with objects exposed in this way.

This particular kind of reaction to stimulus—speech—offers the difficulty that not only must stimulus be offered, but in order to get typical and useful results the subject must have a motive for reacting to it in terms of speech. In general, the direction to respond in such and such a way, was not in itself sufficient. Motivation in the sense of the presence of an audience was often given by the presence and evident interest of the investigator.

If the result is to be anything but mechanical, a feeling of some sort of vitality of connection between the audience and what is said to it is necessary, and is very difficult to achieve. The conditions of the experiment, therefore, though as far as possible under experimental control, were made as little mechanical, as much like ordinary human intercourse, as might be. The fact that I was well acquainted with most of my subjects was, I consider, a great advantage in this respect. Unless the conditions are comparable with those of ordinary intercourse, it seems inevitable that no real speech can result; speech is emphatically a social affair and must be observed under social conditions. Then, too, in order to get any mental content capable of introspection, it was necessary to induce thought processes of some kind, the more original—that is, stimulated by unfamiliar scenes, objects, circircumstances—the better; for speech-motor responses to stimuli, like other motor responses, are very largely automatic, habitual, and therefore exceedingly hard to come at in consciousness. Throughout these experiments the motivation is the weak point; for which reason it has seemed permissible to utilize, whenever they offered, the accidental, spontaneous reports of their mental processes that have come in from some of the subjects. Real thinking is at any rate done in the laboratory in connection with the task of introspection.[59]

Objective Results.

The Time Records.

The following table summarizes for all the experiments the results for the reaction times, that is, the times between the appearance of the stimulus and the beginning of speech or writing. The times are given in seconds.

If the times for the spoken responses in this table are compared with those of the association test and other tests a considerable likeness appears. Sc, Ty, R, By are quick, in practically the same order; Ev, B, E are as before very much slower; T's time, especially for written response, is slower than her previous records would lead one to expect, and Rg's for oral response is rather surprisingly fast.

[59] See Wundt's position, Psychologische Studien, 1907, 3.

Subj.	Spoken Responses					Written Responses				General Average	Percent of increase*
	III. 1 words phrases sentences	III. 2a sentences	IV. b. words phrases sentences	III. 4 cont. speech	Average without 4 — With 4	III. 2b. sentences — time of turning	IV. a. sentences	III. 3 cont. writing	Average		of writing over speaking time.
Ty	3.2"	2.5"	2.3" phrases	—	2.66"	5" / 3.5"	—	9"	7"	4.8"	90
Rg	2.3"	2.3"	2.6" sentences	4.6"	2.4" / 2.9"	10.7" / 8.8"	(12")	—	11.3"	7.1"	346
Sc	2.66" sentences	1.5"	3.3"	2.5"	2.48" / 2.49"	4.2" / 1.8"	—	—	—	3.3"	69
R	2.44"	2.44"	3.6"	2.25"	2.8" / 2.68"	7.3" / 3.3"	9.3"	13.6"	10"	6.34"	160
Ev	3.5" sentences	4.9"	3.07"	7.5"	3.82" / 4.74"	14.4" / 7.2"	6.5"	(1'22")	10.5" (34.3")	7.6" (19")	277
By	2.95"	2.25"	3.5"	—	2.9"	5.3" / 2.6"	22"	—	13.6"	8.2"	83
T	2.8" phrases	6.45"	2.9"	—	4.05"	7" / 4"	—	24.6"	15.8"	9.9"	74
B	4.03" some sentences	4.2"	4.3"	—	4.26"	5.6" / 3.3"	26"	35"	22"	13"	31
E	words 5.2"; sent. 11. "; av. 8.1"	words 3.33"; sent. 8. "; av. 5.6"	phr. 8. "; sent. 9.2"; av. 8.6"	3.75"	7.4" / 6.5"	7.1"	25.5"	33.5"	22"	14.2"	4% decrease

* This comparison was based on the first average under spoken responses, and the times for III. 2b. under written. There seems to be an average normal increase of from 75 to 100% of writing over speaking time.

2 b affords the only available set of reaction times for written responses on which a comparison with the times for spoken responses can be based. The times, as would be expected, are much longer than for oral responses, except in the case of E, who seems to write short sentences at something less than her oral average. She is, as a matter of fact, accustomed to expressing herself in writing rather than in speech, and talks slowly and haltingly. Sc, Ty, and By keep their places at the head of the list, B rises from eighth to fourth place, E from ninth to sixth. R and Rg fall from third and fifth to seventh and eighth respectively. It is evident if these results are to be accepted, and they agree in general with the other records, that B and E express themselves more readily in writing, and that R and Rg do not express themselves in writing nearly so readily as they do in speech. If the per cent of increase in time for written (based on 2 b) as compared with spoken expression (1, 2 a, and Group IV. b) is considered, three of the subjects are seen to add enormously to their time, Rg 346%, Ev 277%, R 160%. Rg and R are not accustomed to writing and show a great disinclination for it; Ev is a writer and his long times may be attributed, in part at least, to his critical attitude toward his work. The increases of Ty and By, 90 and 83 %, may very likely be due in part to this same critical attitude, although there seems to be a normal increase for writing of at least 75%. E's time shows an actual decrease of 4%; if her time for continued speech were considered this decrease would be changed to a very slight increase.

When the directions called for continued writing, say a paragraph or so as in 3, the subjects spent a considerably longer time in preparation. It seems probable from the introspections, that a kind of plan or 'feeling' of the whole is present in mind before this writing is undertaken. Preparation times for this experiment were not taken for the earlier tested subjects but those that were taken vary from 9″ for Ty to over 30″ for B and E and probably considerably more for Ev. Some of the introspections show clearly the presence of a plan.

The average length of time per word for sentences and continued discourse has also been determined, though the data is somewhat incomplete for the earlier tested subjects. The times for continued discourse include pauses of all sorts. The average time per word for spoken sentences (2 a) is .446″, ranging from .245″ for Sc to .83″ for Ev; for continued discourse, it is considerably longer, .744″, ranging from .538″ for Rg to .95″ for Ev and E. The times for writing single sentences (2b) average 1.88″, and range from 1.5″ for Ty, Rg, and By, to 2.44″ for Ev and 2.48″ for R; for continued writing in the form of introspections the average is 2.7″, minimum 1.8″ for By, and maximum 3.8″ for Ev; for continued writing with emphasis on literary expression (3), average 2.76″, minimum 1.95″ for By, the most practiced writer of them all, and maximum 3.48″ for R, the most reluctant. On the whole, By, Ty, and B are relatively somewhat readier writers than speakers; R and Sc are much readier speakers than writers. Rg, T, E, and Ev show relatively little change. It should always be kept in mind that Ev, E, and B are essentially slow reactors.

Average length of time per word, in seconds. From Group III.

	Spoken words		Written words		
	2a	4	2b	3	Introsp.
E	.4	.674	2.48	3.48	2.9
E		.949		3.31	3.08
Ty	.41	.832	1.5	2.12	1.96
B		(.939)		3.12	2.57
Rg	.53	.538	1.5	2.28	2.8
By	.26	.747	1.5	1.95	1.8
Sc	.245	.624	1.9	3.38	3.29
Ev	.83	.947	2.44	3.35	3.8
T		.642		2.52	2.8
Av	.466	.744	1.88	2.76	2.7

Nature of the Vocabulary.

A rather mechanical investigation of the length in syllables of the words used in III, 2a and IV. b, oral, and III. 2 b, 3, and IV. a, written, was made by finding the per cent of words of two or more syllables used by each subject. For speech, the longer words run from 7.5 % of the total for E to 37% for R, with an average of 24%. For writing, the longer words run from 23% for T, to 37% for R, with an average of 29%. For T and By the per cent for spoken words is somewhat larger than for the written; for R, B, and Sc spoken and written are about the same; for the others, the per cent of long written words is more than twice that of long spoken. I should have supposed that the use of more long words in writing would be universal.

A somewhat similar analysis was made of the verb element in the same experiments. A comparison of the per cents for III. 2 a (spoken) and III. 2 b (written) shows that for all but Ev, and By, there is a smaller per cent of verbs in spoken than in written sentences. With the exception of R there is a smaller per cent of verbs in continued than in sentence-length written discourse, an average of 23.6% in sentences, of 17.6% in connected discourse. R has for continued written discourse an unusually large per cent of verbs, 24; and E an extremely large per cent in the written sentence, 38. In the spoken sentence Ev has a very large per cent, 36.7, the next being Rg with 28.7%. There would be a temptation to associate many verbs with highly motor types, were it not that B has very low per cents of verbs everywhere. A further discussion of the verb occurs in connection with the sentence later.

The vocabulary used was studied very carefully, from the results of experiments 2 and 3 of Group III, and of the experiments of Group IV. The particles, conjunctions, prepositions, pronouns, minor adverbs, and verbal auxiliaries, were omitted, and other words grouped according to the classes of the association test,[60] as objective, sensuous, attributive, connotative and abstract (least likely to arouse concrete imagery). The classification is far from ideal but it was at least consistently applied.

Group IV, oral and written, was examined first. The average total number of words classified constituted 50.3% of the whole, of which the averages for each class were: objective 13.5%; sensuous, 6.4% connotative, 5.8%; attributive, 11.4%; and abstract 13.2%. The table below gives the per cents for each subject, and in italic his relative standing when compared with the common average. The numbers giving the relative standing are based on differences of 1%.

An analysis of these results would seem to show that E, Ty, and Rg have the most representative or concrete vocabulary; R,

[60] See Appendix. Association Test.

Vocabulary table from IV.

	ob.	s.	attr.	con.	abs.	tot.%
E	15.6%	14.8%	13.1%	11.6%	6.1%	61.2
	2	*9*	*2*	*6*	*−7*	
Ty	12.5	8.2	14.1	6.6	5	46.4
	−1	*2*	*3*	*1*	*−8*	
Sc	14.4	2.7	18.3	6.2	7.3	48.9
	1	*−3*	*7*	*1*	*−6*	
Rg	15	6.7	14	8.2	10.9	54.8
	1	*1*	*3*	*3*	*−3*	
T	13.8	1.9	10.3	5.7	13.7	45.4
	0	*−1*	*−1*	*0*	*0*	
Ev	12.3	4.3	11	9.3	16.5	53.4
	−1	*−3*	*0*	*4*	*3*	
B	12.6	2.6	10.5	5	18.9	49.6
	−1	*−3*	*−1*	*−1*	*5*	
By	13.5	6.3	5.4	4.3	20.7	50.2
	0	*0*	*−6*	*−1*	*7*	
R	11.7	4.5	6.2	1.6	19.7	43.7
	−2	*−1*	*−5*	*−2*	*6*	
Avs.	13.5	6.4	11.4	5.8	13.2	50.3

By, and B the least. T's record is nearest to an average. The three most representative have been previously diagnosed as highly concrete in their imagery, Ty being also quite verbal. The three least representative are highly verbal. R and B have a good deal of motor imagery, By can be on occasion highly concrete but tends to suppress such imagery, as does Ev, when reading.

At this stage a similar analysis of the vocabulary in Group III, 2 and 3 was undertaken, to see if it would substantiate these results.

Vocabulary table from III. 3.

	ob.	s.	attr.	con.	abs.	tot.%
E	16.8%	2.9%	10.2%	2.9%	12.6%	45.4
	1	*−2*	*1*	*−1*	*−4*	
Ty	15.3	3.4	13	7.9	9.3	48.9
	0	*−1*	*4*	*4*	*−7*	
Sc	12.5	1.9	11	4.8	13.5	43.7
	−3	*−3*	*2*	*1*	*−3*	
Rg	13.5	4.8	7.8	2.8	16	44.9
	−2	*0*	*−2*	*−1*	*0*	
T	18.3	5.9	11.2	4	13.6	53
	3	*1*	*2*	*0*	*−3*	
Ev	11.5	7.8	4.9	4	19.8	48
	−4	*3*	*−5*	*0*	*4*	
B	18.8	0	9.4	1.8	14	44
	3	*0*	*0*	*−2*	*−2*	
By	12.3	2.4	7.8	4.2	19.7	46.4
	−3	*−2*	*−2*	*0*	*4*	
R	18.7	11.2	10	4.9	24.9	69.7
	3	*6*	*1*	*1*	*9*	
Avs.	15.3	5	9.5	4.1	15.9	49.8

The results from the picture material are quite different in some cases. R makes here a representative record comparable to E's for object material, though he still retains his position as most abstract. E, although as before she is among the least abstract, has fallen off in per cent of representative words. Rg is considerably less representative here. Those who remain as before are Ty, in the most representative group, and By and B in the least representative. A consideration of both tables seems to warrant the following conclusions. R, Ev, By, all highly verbal, have the most abstract vocabulary; Ty and E, very highly concrete, the latter non-verbal, the least so. Ty, E, and R, all highly concrete in imagery, though R is also highly verbal, have the most representative vocabulary; B and By, both very verbal, the latter very visual but tending to suppress visual imagery when dealing with words, have the least representative; T, Ev, Sc, and Rg occupy a middle position, all of them having considerable concrete imagery, Ev not so much in connection with words as the other three and more verbal. The results for Group III are probably more trustworthy, since 3 under that group involved a considerably larger amount of material than there is in Group IV.

An examination of the sentences in Group IV as to emphasis and attitude shown gives some interesting results. Emphasis on color and light, E, Ty, and to a less degree, Ev, T, and Rg. Emphasis on shape, line, and size, R—size especially—Ev, Sc, and T and B not so marked. Emphasis on position, R and T, B and Ev not so marked. Literary association and connotation, marked for E, Ev, and Ty. Presence of other association, marked for T, less noticeable for Ty, and Ev. More purely scientific description, most noticeable in R, Sc, and B. Critical attitude, By, showing somewhat in Ty, and Sc. Attitude feeling-toned, E, and Ty, somewhat for T and Rg. An appreciation of *use* is noticeable in R and B. To a very marked degree these results are what might be expected from the diagnosis. (See diagnosis sheets, Chap. IV.)

Literary Excellence.

The more careful and leisurely continued writing of 3, under Group III, and the sentences from Group IV, I undertook to grade as to literary excellence, as I would grade a set of themes, using the markings *A, B, C,* and *D*. Seven years of experience as a reader of themes ought to make such grading fairly reliable. For 3, the subjects ranked as follows: *A,* Ev, and E; *A*—, Ty, and By; *B,* Sc, and T; *C,* Rg and B; *D,* R. R's faults are lack of complete sentence form and poor organization of material; his vocabulary is good. Ty to a considerable degree gets a feeling of her own from the picture instead of what is there; the combination sometimes gives the impression of superficial feeling. By's critical tendency is very noticeable. B, possibly because her phrasing is not due to habit and literary example, strikes out a few extremely effective descriptive phrases.

For IV, a, written, E, Ty, and Ev are *A;* T and Rg, *B* to *A;* By, *B;* R, B, and Sc, *C.* T and Rg do much better with objects; Sc and to some extent By are less actively stimulated by them and write somewhat perfunctorily. When b, the oral expression, is considered a number of changes appear. By heads the list, followed closely by E and Ev; T and Ty are *B;* B and Sc, *C;* Rg and R, *D.* The difference as it shows here between oral and written expression is, in general, what would be expected from the previous records. R, however, who is ordinarily a rather fluent talker, responds here with simple word identifications. The fancifulness of E and Ty, I should not hesitate to attribute to their habit of dwelling a great deal upon concrete imagery. It is possible that Ev's comparative suppression of definite concrete imagery goes hand in hand with his capacity for abstract thought.

The oral discourse of 4, Group III, is of a very rambling and fragmentary nature. Ty, E, and By produce a little material of the standard of literary prose; T, B, and Rg are very fragmentary; R's discourse, though connected, is very rambling; Sc and Ev stumble a good deal, though their sentences are fairly well constructed. Ev's oral expression, however, is far below his literary standard. The more fluent in this test, judged by average time per word, are Rg, Sc, T, and R, in that order; the least fluent, the slow trio, B, Ev, and E. By's record here is slow, but he was fatigued when the test was made. If the comparative number of words to each stimulus card is considered, it is seen that Rg, though she speaks quickly, says much the least; R and Sc are not only quick but say by far the most; E, though very slow, says a great deal, and Ev is not only slow but says little. It is safe to say that R and Sc are fluent; that Ev and Rg are not; and that E is at least talkative. The general character of the content accords with this judgment. The test, however, was not very satisfactory. It should be repeated under something more like ordinary conversational conditions.

In general, those subjects show literary excellence who would, from the work they have chosen to do and the training they have had, be expected to show it. T, however, shows literary promise, and Sc for these quick responses shows remarkably little of the excellence which he really achieves in expository writing.

Mental Content Preceding Expression.

One of the main reasons for giving the tests of Groups III and IV was to see how much could be learned about the amount and character of verbal imagery present before expression in word or sentence occurred. It was felt, moreover, that some light would be thrown upon the processes of thought and probably some upon the genesis of the sentence.

Verbal Imagery.

The following examples will give some idea of the amount and character of verbal imagery, and also of the differences in these regards between the subjects. The responses are in italic, words reported present in mind are quoted.

E. III. 1. Arch of Titus. *Rome.* No verbal imagery. Picture sort of came alive—there was a marble arch. Identified by word.

Row of tents. No response. (Had been asked to respond with a sentence. At end of about 15″ moved as if to write but nothing came. At 20″ was asked for introspection.) I liked the grays in it. Then I recognized the objects and vivified the picture. I did not feel like saying anything. I heard vague circus music like that in Peter Grim.

2b. CHILDREN PLAYING. The falling of the cover card at 5″ was certainly a signal to write, seemed to break into her train of thought. She remembered a situation—concrete imagery—and heard the sentence said to her by the old woman who said it before. *Signorina, lei vuole andare là.*

V. b. VASE. 5″ exposure. No response. First I made out the shape of the vase; then I saw it was like a very spread out white flower with a broad calyx which grew close to the ground. Then I began to think of the verse in the Rubáiyát about the tulip, and could get nothing but fragments.

T. III. 7. ARCH OF TITUS. *Woman in brightly colored clothes.* First thing was a general impression of a "gate" in Italy or Palestine or the like. Found picture pleasant. Liked particularly the blue. Word "Trojan" came up distinctly, quite different from the masses of words present in the mind in connection with picture.

2. a. STEAMER AT CHARLEVOIX. 2″ exposure. *I was surprised at smoke arising.* I don't believe that I think in complete sentences.

The smoke seemed to produce a division of the picture and a sharp contrast between that and the blue water. There is something on the right, a dock or another boat. The struggle to make a sentence was great enough to drown the details of the picture. ...The sentence forming was difficult, only two or three words coming, like "black smoke," "boat," "smoke," etc. I didn't have much difficulty writing this in sentences though.

IV a. CARROTS. 5″ exposure. Remember saying "carrots" to myself. Thought of grocery store (mixed verbal and visual). Saw baskets on floor very indefinitely. May have sort of halfway said "grocery."

Rg. III. 7. ROW OF TENTS. 2″ exposure. *Gray.* Realized that was supposed to say something—no words. Attention was on color.

2 b. LUXOR. Turned 6″. Saw stone figure and started to say something about it, but it didn't work, just a feeling. Then saw—ladies with roofs on their heads. Then sentence came, knew it wasn't right,[61] but association of classical architecture had been called up. *This is a picture of the Parthenon.*

BAY OF NAPLES.—Turned 13″. Confused feeling of too much in the picture to pick out anything to describe. Started to use the city. Then tried to put in the mountain. Began "Picture of a city by the mountains" realized it wasn't a sentence and said to myself—"Oh dear, I can't think of a sentence," realized it was the first sentence definitely thought of so had to put down, feeling sort of trapped.

IV. b. OWL AND FIGURE. (Forgot instructions.) A kind of confused searching for a name—with "The Owl and the Pussy Cat" somewhere in the back of my mind, but knowing it was not at all the name of the objects.

Ev. III. 1. DELPHICA. *That's Michael Angelo's.* I had certain of his painted prophets and sibyls in mind at once, and was trying to identify this.

2 b. JAPANESE CHILDREN. Turned 5″, began to write 13″. *Twins—not twins because one is taller—Japanese children.* I think this is something like the order of my first thoughts, although I am not sure how much of it was really thought in words. I am sure that "twins" and "Japanese" were, before I turned to write. Second item was probably just an image—not in words—an impression of relative size translated into words.[62] Often parts of thoughts are in words, and part in other faint impressions. (In general visual not verbal imagery is suggested by the cards to this artist.)

IV. b. BOOK. *Those are birds—aren't they?* Had to force self

[61] Other cases of censorship: Ty. STEAMER AT CHARLEVOIX, p. 110; B. CANAL, p. 111; R. VASE, p. 117. The matter of censorship is discussed by Pillsbury, The Mental Antecedents of Speech, p. 121.

[62] Pillsbury's statement, "There is never or extremely rarely a sequence of ideas that comes before speech and can be said to be sufficiently detailed to be translated into words" (Mental Antecedents of Speech, p. 121) is too sweeping for the results of these experiments. See Ev. BOOK, p. 109; Sc. APPARATUS, p. 110; R. CHILDREN PLAYING, p. 111.

to say. Quite consciously the sort of thought that you think for your own benefit. Didn't have that thought to communicate, but was trying to identify the little flecks. Little bit more aware of turning it into words. Effort was thing noticed, and afterward a feeling that it should have been a question.

Sc. III. 1. DELPHICA. 3″. *Picture in a gallery evidently. . . . It's a. . . . can't make that out.* Think I had the word "classic" in mind. Roman or Greek. Felt ashamed because not able to place her immediately. What does she mean? Can't name her. Arms attracted attention. Turned to printing, to last word. This was practically little snatches of statement, a good many of the nouns are here as words—they're not complete—very, very short things. Don't call in all the words that would use in expression.

IV. b. APPARATUS 1. 8″. *I see an instrument of some sort.* (Sentence faded out at the end.) Distinct jump from getting the thing and having it ready to express, and expressing it. The jump to expression, 'terming' the thing, a process I wouldn't go through unless I were going to express. I think we go about getting things like that all the time without naming. Satisfied with general nature of it and ready to quit, when it occurred to me that I was to put it in a sentence. Then it didn't *mean* much to me.

Ty. III. 1. BULLOCK CART. 3″. *Japanese—or Javanese—or—Filipino or Cuban.* 6″. *Something tropical.* Saw man's hat right away, Japanese—and bullock, then palm trees in background. No words attached. No words found except those spoken. Didn't think when I said it where Java was or what it was like. Began to collect a geographical scene when said Filipino—to put elements of picture together and notice of what region they were characteristic. Thought palm trees more appropriate to Cuba. The last thing I remember was—what under the sun is in that cart? Not words—just a general sense of puzzling wildly, trying to get something the fruits looked like.

2 a. STEAMER AT CHARLEVOIX. 2″. *It is a boat.* After *Ready,* conscious of modeling sentences like "This is green," etc. Card appeared. Pretty blue harbor. Nice light-house. The "smoke" would be very nice to say something about. (None of this repre-

sents words except "smoke".) I was amazed to hear myself saying *Boat*—hadn't the remotest idea I was going to use that word; in fact, I was trying so hard to think what kind of a boat it was that I felt the word to be inadequate if not inaccurate. Felt regret that I did not say something about the smoke.

By. III. 1. Row of Tents. 3″. *Plattsburg.* Word "tents" was the first word, and "summer camp" came into head. "Plattsburg" came, spoken before thought of, absolutely, unconscious as could be. Was surprised at word when it came out. Afterward thought of military camp at Plattsburg.

Arch of Titus. 2″. *That is an arch of triumph.* I thought it without any hesitation, or any intermediate steps. While saying it, identified the figure as a modern Italian peasant, and so had the *conviction* that the picture was a Roman ruin. "Hadrian" was indirectly concerned in the latter part of my thinking as a definite word image.

R. III. 1. Bullock Cart. 2.8″. *Country.* Had no time to think. It was green.

English Doorway. 2.8″. *Spain.* Looked southern. "Spain" present in mind, felt like muscles working in cortex.

2 a. Steamer at Charlevoix. 3″—5.8″. *Well—this reminds me of Long Branch.* "Atlantic City" was an alternative, very present and probably verbally.

2 b. Children Playing. Turned 3.5″, writing at 6″. *These children are playing a game of which I never was very fond.* Verbal element came in concomitantly with seeing and recollecting. Had most of it in phrases pretty much in mind before wrote. "These" occurred after turning.

Luxor. Turned 3″, writing at 7″. *Alexandria is a very filthy city.* "Egypt," "Alexandria," "filthy," present verbally, and general background of unsanitary conditions which I had been reading about.

B. III. 1. Delphica. 2″. *Woman.* Looking frantically for something to say when the word spoken *popped* suddenly,—seemingly from nowhere.

2 a. Canal. 9″. *That's a pretty drive.* "Drive" came up first,

then "pretty drive," "water," "horse," "pretty horse and buggy," was about to say this when thought verbally, "but it isn't a pretty horse and buggy." "Pretty horse," but this was not complete so looked for something else. Didn't want to say pretty anything, for it sounded silly. Then thought "drive" again and a feeling of push came as I realized the passing of time, and got the above.

IV a. APPARATUS. Exposed 7″, began to write 44″.

The object this time is a piece of apparatus for study of tones, and is called a siren. Followed by drawing. Recognized as piece of our apparatus. Verbal, "what is the brute anyway?" Probably verbal, "piece of electrical apparatus," had some of the feeling of the place it came out of. First thought of "tone" (verbal way down), then "siren." When started to write had a hunch it wasn't electrical. "Don't believe that is electrical." Words may have followed idea in mind, but so far as I can tell they accompanied or were the idea.

These introspections speak for themselves and give an idea not only of the amount and character of the verbal imagery for the different subjects, but of the other mental content preceding expression. If by thought "present as a whole in consciousness before the first word was reached,"[63] Wundt means, as he seems to, something total or unitary that precedes the observation in the mind of any imaginal details, or any development of the thought, then the subjects do not report it,—if present it was not described as part of the imagery content, and could be only an unanalyzable consciousness, of a relationship perhaps. On the other hand, Pillsbury's[64] anticipatory or preliminary intention seems to be lacking also, though it is somewhat a question of interpretation. The Aufgabe may represent here "the general in-

[63] "In such self-observations it became perfectly clear to me that the thought was not formed during the process of its verbal expression, but was present as a whole in consciousness before the first word was reached. At first none of the verbal or other images, which subsequently appeared in running through the thought and giving it expression, was present in the focus of consciousness, but these parts of the thought appeared successively as the thought was allowed to develop." (Incidental introspection during spontaneous thought.) Wundt, Psychologische Studien, 1907, 3, p. 349, quoted by Woodworth, A Revision of Imageless Thought, p. 2.

[64] Pillsbury, The Mental Antecedents of Speech.

tention to express something."[65] The "preliminary intention to express some particular thing, which is indicated by a most general mental content that means the thing in the vaguest way,"[66] is perhaps reported in the experience of Sc (LUXOR, p. 116), who thinks he "really got Egyptian the first thing and then justified it"; though I suppose this might also be interpreted as the total idea of Wundt! The differences between the results of these experiments and the conclusions of Wundt and Pillsbury may be due to the fact that they are considering abstract thought, whereas the material of these tests is concrete—in them the thing attended to may furnish the preliminary unifying idea. Thought seems, in many cases, as Wundt says, not to be "formed during the process of its verbal expression"; for instance, T says, "when I turned to write had that thought and had it in that order—hadn't said it as sentence to myself." In her case, and in Ev's (JAPANESE CHILDREN, p. 109), and in other cases where censorship takes place, notably T's on p. 118, AMALFI, there is indicated the presence of some sort of plan, or idea used for reference, which is not the sentence as expressed. In other records, by highly verbal types, there seems to be nothing that can be discovered previous to speech or wording (By. FAN, p. 122).

What Wundt means by "running through the thought and giving it expression" may occur in experiences like B's, p. 111, CANAL, or R's, p. 111, CHILDREN PLAYING. Shall this sort of thing be called analysis or development? I am inclined to agree with Pillsbury that "The course of each thought is really much more a development of its meaning than a mere analysis of what was present in it."[67] B's report on APPARATUS, p. 112, seems to be of the nature of the development of an identification. Introspections may be interpreted variously; probably Wundt and Pillsbury are interpreting similar experiences in their descriptions of the mental antecedents of speech. It seems obvious, at any rate, that mental content preceding speech varies for the same subject, and from subject to subject—is rather an infinitely vary-

[65] *Ibid.*, p. 120.
[66] *Ibid.*, p. 121.
[67] *Ibid.*, p. 125.

ing process than any set procedure. On this point I think the introspective records may be left to speak for themselves. Sometimes, and this is apparently typical of verbals, there is not only no preliminary or total idea but no analysis or development apparent; the subject's spoken words seem to be all the trace there is of the thought, an automatic reaction to something not observed (By. ARCH OF TITUS, p. 111; B. ENGLISH DOORWAY, p. 119; Ev. CHILDREN PLAYING, p. 121.) Sometimes a good deal of concrete imagery and fragments of words and phrases precede speech (Sc. DELPHICA, p. 110, LUXOR, p. 116; Ty. ENGLISH DOORWAY, p. 116, CASTLE AND SWANS, p. 117). The formulation of the sentence in words before speaking (Ty. APPARATUS, p. 117) is, in these experiments, extremely rare. I think Pillsbury underestimates the amount of concrete imagery preceding speech, but here again the difference may be due to the abstract nature of the thought he is considering, or to his own mental type.

The purely automatic character of much verbal reaction, that is, the lack of conscious imagery preceding it, is clearly demonstrated. Everywhere the process of wording itself seems automatic, incapable of introspection. The most one can do is, as Pillsbury says, "to pass upon this product as to its adequateness to the purpose in hand."[68] This automatic character applies to sentences as well as to words and phrases; there are, as it were, automatized sentence "patterns," to which our thought has been adapting itself since our earliest experience with speech.

All the subjects are at least somewhat automatic in their verbal reactions, all are somewhat verbal in thought content; but there are individual differences. B, Ev, R, and Sc are noticeably verbal in thought, R and Sc also noticeably automatic in reaction, as are By, Ty, and, less markedly, T and Rg. By and T are comparatively verbal in thought, though more automatic. E shows least evidence of either; the verbal content of her mind seems to consist largely of quotations and the like, and though talkative, she has very slow reaction times and rate per word.

[68] Pillsbury, The Mental Antecedents of Speech, p. 121.

Judgments.

It is impossible to ignore the fact that many of these reactions, if not, indeed, all of them, represent judgments. They range from a simple automatized identification or recognition to the expression resulting from elaborate though rapid processes of consideration of evidence. To those that have been given, the following, perhaps more clear cut, may be added.

The simple identification. (See E, ARCH OF TITUS, p. 107; Ty. STEAMER AT CHARLEVOIX, p. 110.)

B. III. 1. SNOW SCENE. *Brown City.* Identification. Forgot about the sentence instruction, and responded with the first thing that came.

Ty. III. 1. AMALFI. *Amalfi.* Thought of word the moment I saw it.

Ev. III. 2 b. LUXOR. Turned 4″. *That is in Cairo.* He thinks simply the words "in Cairo" had come when he turned.

Verification present. (See By. ARCH OF TITUS, p. 111; Ev. DELPHICA, p. 109.)

T. III. 2 b. BAY OF NAPLES. Turned 4″. *That's Vesuvius.* The card was nice. I noticed the yellow houses in the foreground and the lake, and the nice colors in the sky. Sort of squinted to see if the mountain in the background was a smoking mountain —it reminded me of pictures of Vesuvius. Then I cast about for a sentence, though it came more easily than usual. I think perhaps wonder about smoke was good sentence material, but I am sure it didn't come to words.

Sc. III. 1. ARCH OF TITUS. 1″. *That's the picture of an arch.* Had the word "triumphal" in mind, think I dropped it to save time. Idea of Roman triumphs, dimly, not verbal. Felt big background of things in there, sort of sifting around. Thought also of fact that it was Italy—of fitness of arch to Italy. Noticed the peasant girl in foreground, strengthened Italian impression. Spoke. (This is a very good illustration of the enormous amount of suppression or exclusion of mental content at the point of expression.)

Judgments rising out of feeling.

Ev. III. 1. BULLOCK CART. 3″. *It's cruder than the last one.* It carried a distinct impression of cheaply-colored-photograph.

Rg. III. 1. INVERNESS STREET. 2″. *I don't like it.*

By. III. 2 a. AMALFI. *I expected that to be colored.* When I thought before the picture was shown that I wished to change the form in which I had been making statements, I thought of the noticeable green in the last picture shown, and was planning to respond in some way to the color of the picture. When it came I felt somewhat confused and expressed my confusion in the sentence.

These judgments seem to be almost, it not quite, as immediate as the identifications; they represent feeling in some way, rise out of the presence of a personal element in the reaction, such as surprise, confusion, approval, or dislike.

More elaborate forms of judgment. (See Ev. JAPANESE CHILDREN, p. 109; Ty. BULLOCK CART, p. 110; B. APPARATUS, p. 112.)

Sc. III. 2 b. LUXOR. Turned 1.6″. (*That is*) *the picture of an Egyptian temple.* Spent most of my time trying to get the proper national adjective. Had Greek and Roman art in mind. Decided from character of figure in foreground and of columns (bigness and roundness in figure and in columns felt to be Egyptian) that it was Egyptian. Did this roughly. Then decided to call it "temple" because those ruins mostly are. Turned, got "That is," and wrote.

"Temple" is the only thing he is sure he named. Thinks really got Egyptian the first thing and then justified it. Thinks he didn't have words for Greek and Roman, just an other-arts-peculiar-to-regions-down-there feeling. Talked while writing—"I don't think in sentences. I don't gather my material in sentences."

Ty. III. 1. ENGLISH DOORWAY. 17″-25″. *That door—It's an English door—some kind of late Gothic.* Pretty color—general impression but not a word. "Writing is upside down." Why? Fountain surrounded by "flowers." Is it a door or an archway? Thought of a door in "Martha Cook," visual. Kind of bringing evidence to bear. "Tower" and skyline are battlemented. What kind of doorway is that? Had other words I don't remember. Forgot directions somewhat.

2 a. CASTLE AND SWANS. 3″. *Not Chillon....* Has composition of usual views of Chillon, but that is not ruinous as this is, and is different color and is right on edge of lake. Visual, comparison of this picture with one I have of Chillon. I was not conscious of having to make a sentence, but the moment I said it I realized I had no verb in it. Neither saw nor heard the word Chillon.

IV. b. APPARATUS. *What in the world!* It's the back of something interesting (not words, it looks dusty and dingy and regulating), how perplexing. "What in the world" on two distinct occasions before said it aloud. I think it wasn't articulated.

By. II. 2 b. CHILDREN PLAYING. Turned at 3.5″ and began to write. *That little boy is larger than my son.* The figure of the boy attracted my attention because of its position in the focus of the picture. I thought immediately of my own son who is perhaps a year younger than the boy in the picture. I had a very vague impression of him in an overall suit. While writing it down wanted to extend it but restrained myself; realized that a great deal had been added to thought content since the statement first occurred.

III. 1. DELPHICA. 3″. *Michael Angelo.* The picture aroused only a desire to identify it with a certain artist. I had a confused idea that the picture looked like the Medici statues of Michael Angelo. (Did not think it was one of them, but have a sort of schematic abstraction about a lot of artists in my mind, and think of those pictures as representative of Michael Angelo.) And felt sure that he was the painter, although I was not sure of any further facts.

R. IV. b. VASE. *Oh, dish.* For a moment cast around for technical word and didn't find it. Wanted to say "goblet," but it was not transparent; had "basin" in mind too, and "fountain"...

B. III 2 b. PERE MARQUETTE FLYER. Turned 3″, writing 5″. *The train's on the track.* Had a feeling of wreck, I suppose from the smoke. It did not come up as a word—just an indefinite. Then thought of possible location of scene—"California" (verbal), and then west (indefinite). Idea of train wreck was in the background of consciousness and this sentence came up.

These processes of judgment are evidently carried on in many cases up to the point of expression, without words or with only an isolated word here and there, and with the aid of much concrete imagery. They come to expression in a single word or phrase as readily and satisfyingly as in a sentence. There does not seem to be any peculiar or necessary connection between a judgment and the sentence form or the presence of a verb.[69] Judging from the introspections and the statements of a number of the subjects, thought not only does not have to take place in related verbal form, or sentences, but it rarely does so take place. The verb, moreover, seems to be the least essential, the most artificial, part of the expression, at least in connection with this sort of material, where it is with few exceptions, whether present or understood, a form of *to be*.[70] (See Sc. p. 116; Ev. pp. 115, 119; B. p. 119; and Ty. p. 119). The verb that is distinctly the name of an action may occupy a different position; if the tests had called out narration the results might have been different. The exceptions to *to be*, mentioned above, occur in connection with the presence of feeling, where the verb represents the essential thing in the judgment, the feeling. That is, the verb does not represent an assertion, it is not a criterion of judgment.

Genesis and Form of the Sentence.

I add a few more introspections bearing more particularly on the genesis and form of the sentence.

Rg. III. 2 a. AMALFI. 3″. "Monk" was the first word that came; then seeing stream I connected the two by saying, *Monk is sitting by the stream.*

T. III. 2 a. AMALFI. 5″. *A rather gray sky was the thing that impressed me.* Could have said sky was grey color, but that wasn't what I was thinking of, and wouldn't reproduce my thought.

2 b. I am conscious from the beginning that I have to make

[69] Messer, Untersuchungen über das Denken, pp. 96, 105.
[70] Meader, The Development of Copulativ Verbs.

a sentence. Think the sentence "I've got to make a sentence" is in a way verbally present. When the picture comes the idea of making a sentence is overshadowed by the desire not to make a kindergarten sentence.

B. IV. b. OWL AND FIGURE. *The first thing was a youngster and then an owl.* With signal *Ready* looked into outer room and could just distinguish a patch of white and thought that must be object, so watched there. Had hazy idea of a cup, though was not aware of this, until I found it was not a cup, when I felt slightly disappointed. Had the feeling of recognition and "youngster" popped into mind. Turned to other object, "owl" came. Then thought—indistinct verbal—"you must react." Meantime "youngster" and "owl" had been running in my mind, so I said it.

III. 1. ENGLISH DOORWAY. 5″. *A beautiful square* sprang up and escaped before I could notice whether it was complete or not.

2 a. STEAMER AT CHARLEVOIX. 2″. *That's the steamer at Charlevoix.* Recognition. "Steamer" came to mind first, although I was conscious at the same time of water and pier. Thought "I have to have a complete sentence," and got "Steamer at Charlevoix," which was again censored and "That's the" added.

Ty. (See III. 2a. CASTLE AND SWANS, p. 117.)

Comment on 2 of IV a. No sentence tendency at all. When I have to write sentences always have to stop and think what kind of a verb would be nice. That's what makes a sentence get written slowly—have to fuss about the verb.

Ev. IV. a. CHINESE BAG. I continually safe-guarded myself toward having a sentence before I expressed any detail. *"It was a piece of fancy work*—followed by participial phrase twenty-three words long.

BOOK. *Those are birds—aren't they?* Had to force myself to say. Quite consciously the sort of thought that you think for your own benefit, didn't have it to communicate. But was trying to identify the little flecks. Little bit more aware of turning it into words.

The presence or absence of a principal verb in these responses from III. 1 and 2, and the difficulty revealed by introspection in achieving a verb, correspond closely to the subject's per cent of verb element for spoken responses (based on III. 2 a and IV. b) and almost as well, Ty not having the success that might be expected, to his per cent for written responses (based on III. 2 b and 3, and IV. a). Ev, By, R, and E are the most successful in getting complete sentences and have the highest per cents; Ty, B, Sc, and Rg have the lowest per cents and Ty, B, and Rg the greatest difficulty, Sc, a very flexible type, not so much.

I was interested at this point to see if any connection would appear between these results for individuals and Meader's[71] statement for peoples: "It is especially among peoples whose thinking is of a concrete tipe that we find specific forms of copulativ expressions least developt." In the first place it should be noted that the subjects are dealing with very concrete material, and that this may account for their difficulty in achieving complete sentences, in using the more abstract verbs. From the examination of vocabulary (pp. 103-105) and from other classifications, the highest proficiency with the copula would be expected of R, Ev, By, and B; the least of E, Ty, Rg, and possibly T. The subjects actually most successful at sentence-forming, and to a large extent this means a ready use of the copula, are, as we should expect, R, Ev, By, and, as we should not expect, E. This exception may be explained in part by E's being a very slow and self-conscious reactor in these experiments, and given in ordinary conversation to talking as she would write, that is, in a rather literary and formal fashion. Those who have most difficulty with sentence-forming are Ty, Rg, to a less extent T, as we should expect, and B, whose record is verbal and abstract. In partial explanation of B's lack of success it should be remembered that she is a reluctant speaker and writer at any time, and an inflexible type. The matter is an interesting one for investigation.

The connection between achieving a sentence and having a motive for communication or expression comes out very clearly. When there is no such motive there is likely to be "a wild clawing

[71] Meader, The Development of Copulative Verbs, pp. 197.

for a sentence," though to some subjects expression is so habitual a process that this extreme is avoided. Sometimes the desire to express an idea or opinion to the investigator has a motivating effect. The situation which most easily produces a sentence in this work, and is likely to produce one of other than "kindergarten" variety, is one that is in some way feeling-toned. The verb is present because it is representative of the reaction.

In III. 4, where there was a continual oral response, there is a very noticeable tendency to omit the verb, especially forms of the verb *to be:* This tendency, here as elsewhere, is particularly noticeable in pure, or passive, description. In T's description of the Fountain there are two main verbs and one participle in ninety words. In By's oral descriptions, which were unusually well organized with many somewhat complicated sentences, the more purely descriptive sentence occurs without a verb, which if there would be a form of *to be,* four times out of twenty sentences. The presence of feeling, here also, seems to be an energizing factor; Rg, who is especially given to omitting verbs in both oral and written discourse, when she reacts to The Two Boats says "That is very pretty. I like that. I like the sunset line and the water," etc.

All the previously unquoted responses that might have been affected by the presence of feeling follow. They are marked by quick times and the presence of a verb.

Rg. III. 1. INVERNESS HIGH STREET. 2″. *I don't like it.* Antagonism was to task—sentence making—not to the picture. Had a feeling of wanting to push it away.

By. III. 2 b. PERE MARQUETTE FLYER. Turned 2″. *I like the green color in that picture.* Verbal image of "green" present before speaking.

Ev. III. 2 b. CHILDREN PLAYING. Turned 4″, wrote 8″. *That is a funny little chap.* Sentence came naturally and I was not conscious of any process of formation.

T. III. 2 b. PERE MARQUETTE FLYER. Began to write 3″. *That's a nice train and the water in the lake seems to curve down toward the track.* This picture was more interesting and attractive. I think the sentence came quite quickly and verbally. I had an opinion about the picture, was not conscious of any struggle. When I turned to write had that thought and had it in that order—hadn't said it as sentence to myself.

E. III. 2 a. STEAMER AT CHARLEVOIX. 4″. *I wish I was on that boat.* Imagery reported visual-concrete and unanalyzable.

Ty. IV. b. OWL AND FIGURE. 2″. *Oh cutey!* Saw the word at the same time as said it. All three processes (including looking at figures) going on at once.

Rg. IV. b. APPARATUS. 2″. Started to say, *Oh I don't* like it, but changed after *don't* to I *can't make it out.* Rg reports that the psychological effect on her of these experiments is quite different from that of the cards, the attitude of receptiveness is different. "The way it comes—it is distinctly pleasurable. Maybe because they are objects and not cards, but I rather think it is in the completeness of the way they appear, the suddenness, no distraction. There was a feeling of life about the process."

By. IV. b. FAN. The first impression of the fan was a feeling of pleasure which had nothing whatever to do with words or any formulation of thought. Even when I began to say what I did I was still "enjoying" the fan more than thinking about it. I was not sure as I spoke that there was any sense in what I was saying. *I suppose it's an added beauty to intricate design to have it made of something very solid like ivory.* (Directed to take his time. Finished in eleven seconds.)

The lack of verbs is undoubtedly due in part to the conditions of the experiment: to a feeling of hurry due to the timing, to the lack of ordinary conversational motive, to the fact that descriptive writing is asked for in several tests, and in others is naturally called out by the concrete material and the situation. Before any valid conclusions could be drawn as to the presence of verbs in oral discourse, at any rate, experiments which would tend to bring out a different kind of comment would have to be arranged.

CHAPTER VI

CONCLUSIONS.

From the results in Chapters II, III, and IV, it seems evident that the imagery type, or type-group, of an individual, though complex and varying somewhat from task to task, may yet be determined, and determined with sufficient clearness to make possible a rough grouping of individuals. A study of these types and groups in relation to the verbal expression of the subject and the mental processes preceding it may, then, be undertaken.

Can any influence of these types upon expression in language be observed?

From the results of the experiments described in Chapters III and V it may be said that the imagery type affects expression in language somewhat with reference to the type of vocabulary. I have always doubted the validity of the tests made on school children by Stern,[72] Colvin,[73] and others, by which the imaginal type of the child was determined from the types of words preferred. Such a test would, of course, be much more reliable with little children than with adults, in many of whom the process of suppressing concrete imagery has gone a long way, as in the case of Ev. I was somewhat surprised, accordingly, when my study of the vocabularies used yielded something like positive results, though, to be sure, attacking the problem from this side is a different matter. The subjects who proved to have the most representative vocabulary, the largest proportion of words that might be expected to call up concrete imagery or sensations, were E, Ty, and Rg, all of whom had previously been diagnosed as highly imaginal types. T, though very imaginal, has not a very large vocabulary and is not accustomed to expressing her concrete mental content in words, as are the other highly imaginal types.

[72] Stern, W., Die Aussage als geistige Leistung und als Verhörsproduct. Experimentelle Schuler-unterschungen, 1904.

[73] Colvin, S. S., Method of Determining Ideational Types, 1909.

Of those who used the largest proportion of abstract terms, R, By, Ev. and B, all but Ev have been shown to be highly verbal; By with a tendency to suppress concrete imagery in connection with words; B with a tendency to use complex and dim imagery, often of an unanalyzable type; R, with a good deal of concrete imagery, largely motor, present in mind during reading or talking. The apparent discrepancy in the case of R, however, is really only the other side of a double tendency; though he has the largest per cent of abstract terms in the results from Group III, and the next largest in the results from Group IV, he has also, in the latter case, the next largest proportion of representative words. Ev's record is only fairly verbal; his strong tendency to use words of a rather complex nature, connotative and abstract, is to be correlated probably with the very large amount of mental content which—though a consideration of his introspections will, I think, convince the reader that he is an unusually keen and intelligent observer of the processes of his mind—he is unable to analyze. At the extremes, at any rate, it is true that the habitual use of much concrete imagery produces a representative vocabulary, and the lack of it a less representative, more abstract vocabulary. The poets E and Ty, I am interested to note, fall into the first group. Of the four using a more abstract vocabulary, Ev, B, By, and R, Ev, By, and R, in my judgment, have the largest working vocabularies of any of the subjects tested in the second part of this investigation; and B is very verbal in thought.

To a considerable degree the ability to give a quick oral response in Groups III and IV is correlated with quick time records in the word association and other tests. There is a difference for the subjects between oral and written expression, R and Rg being very much slower in written, and B and E faster. The tests of Groups III and IV show conclusively that word responses are often purely automatic, not preceded by any verbal imagery. The subjects who show this automatic tendency most markedly here are those who showed it also in the association test. The habit of automatic verbal reaction may occur where the use of words in thinking is comparatively slight.

This automatic reaction in words probably accompanies great fluency, or facility, in the use of words, and explains how such facility if not carefully checked may produce expression that is far from effective; for the automatized vocabulary is narrow and conventional, and represents very quick and often, therefore, very superficial identifications or judgments.

The introspections covering the period just preceding verbal expression show that words, phrases and sentences occur more or less freely in the mental content, the amount of this verbal imagery varying with the subject. It is evident, however, that these verbal elements do not by any means make up the whole stream of thought; they occur there in connection with a great deal of concrete imagery, some of it dim, vestigial, symbolic, some of it vivid, representative, and with other content that so far as these experiments go is unanalyzable. These other factors, like the comparative amount of verbal imagery, also vary demonstrably with the individual.

For the subjects that I have examined at least, thinking is not carried on primarily in connected verbal elements, in "literary form." Most of the sentences which occur before expression in the process of thought are, in truth, not essential parts of that process at all, but communication by the thinker with himself; they are critical, mandatory or the like. "I must wait till I have a complete sentence"; "but it *isn't* a pretty horse and buggy"; "What in the world!" "Oh dear, I can't think of a sentence." The reason why they are not as a rule recognized by the subjects as sentences for response is that they are not integral parts of his thought process, they are not in the line of his task, but by-products.

Concrete imagery, either definite or vague, and thought content so vestigial or complex or unrelated to any of the content usually described as imaginal as to be unanalyzable and undescribable by the subjects, function in these processes of thought. In my work upon unanalyzable forms of mental content I am well aware that I am on dangerous ground, the territory of imageless thought. But my concern is with a demonstration that thought processes occur in forms very far removed indeed from verbal, in forms too complex and syncopated and swift to find automatic expression in words; not with any demonstration that this thought content is imageless in character.

The content of thought is, however, so far as my subjects were able to go with introspection, often imageless. It does not contain what in these experiments we have considered imagery—centrally aroused content of the same character as peripherally aroused sensations, or not differing from them in any other way than degree. Even in the thinking of the most imaginal subjects a great deal of content unanalyzable into images occurs. It does not seem to any of them that sensations like those from the chair on which they sit, or the lunch they have lately eaten, can be even remotely identified with the extremely complex and varying thought units that are continually presenting themselves in consciousness. Nor can all imageless thought be explained as the result of progressive automatization of any sort; the first appearance in mind of a significant relationship seems typically imageless. This imageless content may be preceded or followed by imagery; it seems possible that its accuracy may depend directly or indirectly upon the quality of previously experienced images, a definite and vivid imagery giving rise to right conceptions of likeness and difference. It is possible that kinds of relationships are recognized when they occur, or that the beginnings of arousal of many related images[74] may make a recognizable whole —of which the group relation, the unity, the togetherness, is the outstanding thing. Or it may be that such a togetherness may play its part in mental processes without even the near-presence of imagery in consciousness. I agree with Woodworth[75] when he says, "It appeared that imageless thought, the mere gross fact of observation, had come to stay, and that the only question was what to do with it." But it does not seem to me that Woodworth has helped matters much by adding the mental percept as the element alone which is recalled, if he has distinguished it from image, as he seems to have done, on the ground that it may be

[74] Ach, Willenstätigkeit und Denken, p. 217.

[75] Woodworth, R. S., A Revision of Imageless Thought, Psch. Rev. Vol. XXII, No. 1. Jan. 1915.

isolated. We have in practice always considered the image capable of isolation; we have, for instance, been able to conceive of abstraction. His discussion suggests anew the need of a treatment of what we mean by image, and particularly of a more extended treatment of the relation between image and mental percept as Woodworth conceives them. And I cannot see that in mental percepts, each of which is "specific, and contributes specific content," he has provided any better explanation for the presence of relationships in mind than we had before.

Thinking in words is not necessary either to clear thought or to clear expression. The expression will often follow purely automatically, as we have seen. By's account of his reaction to the ivory fan (p. 122) is an excellent example. Processes of judgment, which find expression in clear-cut sentences in from one to two seconds, go on without any demonstrable help from words.

I should like to repeat here, what was said in the introduction, that I am not under-valuing in the least the importance of language to thought. Language affords the means of social intercourse by which thought is fostered; its symbolism makes possible the development of the higher processes of thought. I am interested only to show that the sustained verbal, grammatical form of spoken language, of communication, is not the native tongue of thought, which is a more complex process. The writing of clear English results from clear thinking, undoubtedly, but not necessarily from clear thinking in words. Expression may be automatic, and it may be, as it is often described in the introspections, a "terming," a wording, a translation into words. And this translation process is easier for some types than for others, inasmuch as the type influences such matters as the nature of the vocabulary, and the verbal habit of the individual, and may even incline some individuals to deal with some sorts of materials rather than with others. The process of wording, however, if it is not immediately the cause of clearness, is at least a test of it, a test of the thought's social availability, a means of projecting it, for criticism either by others or by the self.

Expression in language, even for those who are practiced in it and make a business of it, is difficult even in words and all but impossible in sentence form, unless there is present a motive for communication or expression. A certain degree of excitement due to the presence of an audience—and the audience may be only the self—a desire to communicate, or an element of excitement or feeling due to the effect of the stimulus upon the person, giving him a desire to express himself, seem to be necessary to any adequate functioning of the power of expression in language, or presumably, in any other form. As to the occurrence of the verb, description, which is the form of discourse under which most of the speech and writing educed by this experiment falls, seems a comparatively verbless form. And it is certainly true that judgments come to expression, expression that seems perfectly satisfactory to the speaker and clear to the hearer, without the verb, except when action or personal reaction is the center of the thought. It is almost enough to make one conclude, as Meader seems to, that the complete sentence form is very often not natural or essential, but a conventional requirement of the rhetorician.

Though the individual is driven to *communicate* usually in verbal form, his imagery type will influence his choice of a means of *expression*. Literary excellence will depend somewhat upon the vividness and clearness and accuracy of imagery, even if only as a prerequisite to the growth of more complex and abstract forms of thought. Too great suppression of concrete imagery, too much substitution of abstract and symbolic forms of thought, will impair the vivid and representative quality of writing.

Summary of Conclusions.

I. Types of imagery, though complex, may be determined with sufficient clearness to make possible a study of their correlations with other processes.

II. Imagery types influence the kind of vocabulary, and to some extent the time necessary to react verbally.

III. This verbal reaction is more or less automatic in character, varying with the individual and with the originality of what he has to say.

IV. Words, phrases, and sentences occur more or less freely in the thought process—varying with the type of the individuals.

V. A great deal of imagery other than verbal is present in the processes preceding speech. It may be present as part, or all, of the process of judging; and may be very vague, or so vestigial or complex or unrelated to the content usually described as imaginal as to be unanalyzable, without affecting the clearness of the thought.

VI. This investigation has been seriously affected by the fact, which comes out clearly in the course of it, that any adequate verbal expression, even for those who make a business of it, is dependent upon a motive for communication or expression.

APPENDIX.

Detailed description of experiments used in Mental Diagnosis.

I. Reading of descriptive passages.

First five read silently as nearly normally as possible:

1. There is a place in front of the Royal Exchange where the wide pavement reaches out like a promontory. It is the shape of a triangle with a rounded apex. A stream of traffic runs on either side, and other streets send their currents down into the open space before it. Like the spokes of a wheel converging streams of human life flow into this agitated pool.... Blue carts and yellow omnibuses, varnished carriages and brown vans, green omnibuses and red cabs, pale loads of yellow straw, rusty-red iron clanking on paintless carts, high white woolpacks, grey horses, bay horses, black teams; sunlight sparkling on brass harness, gleaming from carriage panels; jingle, jingle, jingle! A... jingle, too, of colour; flecks of colour champed, as it were, like bits in the horses' teeth, frothed and strewn about. (Jefferies. The Story of my Heart, p. 87. Longmans, 1883.)

2. Throughout the winter of 1861-62, McClellan had under his immediate command double the force of the Confederate general, Joseph E. Johnston, but he could not be induced to take the field. In March, 1892, he at last assumed the offensive. Instead of maneuvering Johnston out of his fortified position, and attacking him on the first opportunity, McClellan decided to transport his army to the peninsula formed by the York and James rivers, and advance upon Richmond from the east instead of from the north. By pursuing this route, he would avoid crossing the Rappahannock, Rapidan, Pamunkey, and Mattapony rivers, and would compel Johnston to abandon his camps near Bull Run and march southward to the defense of the Confederate capital. (pp. 507-509, Channing's Students' History of the United States. Macmillan, 1915.) This was followed in all cases by a reproduction, and in several cases by another passage of a similar

nature, to test the result when the subject was expecting to give a reproduction.

3. So she came holding her dress with one fair rounded arm, and her taper before her, tripping down the stair to greet Esmond.

"She hath put on her scarlet stockings and white shoes," says my lord, still laughing.

"Oh, my fine mistress! is this the way you set your cap for the captain!" She approached, shining smiles upon Esmond, who could look at nothing but her eyes. She advanced holding forward her head, as if she would have him kiss her as he used to do when she was a child.

"Stop," she said, "I'm grown too big! Welcome, Cousin Harry," and she made him an arch courtsy, sweeping down to the ground almost, with the most gracious bend, looking up the while with the brightest eyes and sweetest smile. (The History of Henry Esmond, Bk. II, ch. 7.)

4. Who hath smelt wood smoke at twilight?
Who hath heard the birch log burning?
Who is quick to read the noises of the night?
Let him follow with the others, for the young men's feet are turning
To the camps of proved desire and known delight.
(Kipling. The Feet of the Young Men.).

This was followed in all cases by a reproduction.

5. Ah, bitter chill it was!
The owl for all his feathers was a-cold;
The hare limped trembling through the frozen grass,
And silent was the flock in woolly fold;
Numb were the Beadsman's fingers, while he told
His rosary, and while his frosted breath,
Like pious incense from a censer old,
Seem'd taking flight to heaven without a death,
Past the sweet Virgin's picture, while his prayer he saith.
(Keats. Eve of St. Agnes.)

This was used in a few cases only, where the results of 4 were not good.

Two read aloud by the subject:

6. Then I rested, sitting by the wheat; the bank of beach was between me and the sea, but the waves beat against it; the sea was there, the sea was present and at hand. By the dry wheat I rested, I did not think, I was inhaling the richness of the sea, all the strength and meaning of the sea and earth came to me again. I rubbed out some of the wheat in my hands, I took up a piece of clod and crumbled it in my fingers—it was a joy to touch it—I held my hand so that I could see the sunlight gleam on the slightly moist surface of the skin. (Jefferies. The Story of My Heart, p. 113. Longmans.)

7. Time, now that the deed was accomplished—time, which had closed for the victim, had become instant and momentous for the slayer....The thought was yet in his mind, when, first one and then another, with every variety of pace and voice—one deep as the bell from a cathedral turret, another ringing on its treble notes the prelude of a waltz—the clocks began to strike the hour of three in the afternoon.

The sudden outbreak of so many tongues in that dumb chamber staggered him. He began to bestir himself, going to and fro with the candle, beleaguered by moving shadows, and startled to the soul by chance reflections. In many rich mirrors, some of home design, some from Venice or Amsterdam, he saw his face repeated and repeated, as it were an army of spies his own eyes met and detected him; and the sound of his own steps, lightly as they fell, vexed the surrounding quiet. . . .

The faint, foggy daylight glimmered dimly on the bare floor and stairs; on the bright suit of armor posted, halberd in hand, upon the landing; and on the dark wood-carvings, and framed pictures that hung against the yellow panels of the wainscot. So loud was the beating of the rain through all the house that, in Markheim's ears, it began to be distinguished into many different sounds. Footsteps and sighs, the tread of regiments marching in the distance, the chink of money in the counting, and the creaking of doors held stealthily ajar, appeared to mingle with the patter of the drops upon the cupola and the gushing of the water in the pipes. The sense that he was not alone grew upon him to the verge of madness.

(Stevenson. Markheim.)

Two read by the investigator to the subject:

8. Imagine two steel knife blades with their keen edges crossing each other at right angles, and moving to and fro. (Used by Miss Fernald. James. Psychology II. p. 452.)

9. (In cases where *Markheim* was familiar selections from other short stories were used.)

Presently the notes of a piano were awakened to the music of a hymn, and the voices of many children took up the air and words. How stately, how comfortable was the melody! How fresh the youthful voices! Markheim gave ear to it smilingly as he sorted out the keys, and his mind was thronged with answerable ideas and images—churchgoing children and the pealing of the high organ; children afield, bathers by the brookside, ramblers on the brambly common, kite-flyers in the windy and cloud-navigated sky; and then, at another cadence of the hymn, back again to church, and the somnolence of summer Sundays, and the high genteel voice of the parson (which he smiled a little to recall), and the painted Jacobean tombs and the dim lettering of the ten commandments in the chancel. (Stevenson. Markheim.)

II. Spelling backwards, and pronouncing from words spelled backwards.

1. Spelling backwards.

Oral	Written
1. friendliness	sequestered
2. substitute	equivalent
3. assurance	credibility
4. simplicity	utterance
5. cylindrical	temperament
6. vivacious	mischief
7. manuscript	reverence
8. insatiable	witchcraft
9. heterogeneous	promiscuous
10. intersperse	fictitious

The time was taken by the stopwatch from the moment of pronunciation to the spelling of the last letter.

2. Pronouncing from words spelled backwards.

One letter per second.	Two letters per second
1. glance	assertion
2. identical	analytic
3. broadens	attached
4. chasm	amiable
5. equipment	Belgium
6. Ethel	pronounce
7. mobiliation	abbreviate
8. solve	principle
9. quotient	raises
10. system	potential
11. mathematics	salamander
12. grammarian	equivalent
13. literature	exclamation
14. linguistic	rudimentary
15. democrat	homogeneous
15. progressive	genuine
17. implicit	conclusion
18. Hungary	definition
19. fashion	Michigan
20. fundamental	symmetry

The time was taken from the speaking of the first letter to the beginning of pronunciation.

III. Memory of various kinds of symbols. Exposed for 10 seconds.

Six items

1.	Z	2	V	2.	8	XL	4
	6	o	N		VI	3	ii

Nine items

3.	h	VII	A	4.	6	V	9
	4		s		X	3	VII
	H	IV	1		2	8	IV
5.	5	XL	7	6.	B	4	t
	3	o	IX		=	m	XI
	16	VIII	XI		iii	\	1

IV. Memory of words alike in sound but not in appearance. Exposed for 15 seconds.

Test a.	cent	rays	cite
	raise	site	sent
	sight	raze	scent
Test b.	pair	air	you
	ere	yew	pear
	ewe	pare	heir
Test c.	so	rein	sow
	I	sew	rain
	reign	eye	aye

V. Word lists.

1. Rhyming lists. One minute allowed to write all words

which occurred as rhyming with a given word. All lengths and proper names allowed. Words: home, speak, case, hope, low.

2. Lists of words grouped according to spelling. Time, one minute. Endings used: -one, -ough, -ose, -ave, -ine.

3. Lists of words from endings given, as in 2, grouped in columns according to sound. Time, two minutes. Endings used: -are, -ove, -ear, -ead, -oth.

VI. Memory of words spelled alike but pronounced differently.

1. Words read once by experimenter and reproduced orally by subject.

wĭnd	lĭves	rōw
băss	măll	līves
rôw	wīnd	băss

2. Words read once by experimenter to subject, who follows on a list which he holds, of the same words with no indication of their pronunciation. He then thinks through the words once with the list still before him, and reads them aloud from the list. All he is asked to do is to keep the auditory difference between the words.

lĕad āye dŏve bōw aȳe dôve lēad bôw rĕad

VII. Memory of pictures. Experiment as first used drawn from Miss Fernald's work.

1. 8 picture postals, 4 colored, 4 uncolored, exposed for 10 seconds each. To be described as fully as possible. Introspections taken to throw light on methods of learning and of recall.

2. 8 picture postals, all colored, exposed for 10 seconds each. 4 described immediately, 4 after another experiment has been done.

Experiment as used later. Cards, both colored and uncolored, were shown for periods of 2, 4, and 10 seconds. Some of each of these were recalled after a week's interval.

The Free Word Association Test.

The material from this test was arranged for study in such a way as to give on a single line the stimulus word, its part of speech, its type (objective, sensuous, or the like), its known associations (as with previous experiments), the reaction word, its part of speech and type, the type of the reaction (information drawn from introspections), and the reaction time. The list of words is given below. The abbreviations indicate the probable type of the word: Ab.—abstract, ob.—objective, s.—sensuous, at.—attributive, con.—connotative.

1. florid—at.
2. twilight—con.
3. fly—ob.
4. chill—s.
5. prose—ab.
6. quince—ob.
7. critical—ab.
8. rippling—s.
9. treasure—con.
10. over—ab.
11. drab—s. or at.
12. hum—s.
13. brook—ob.
14. wind—ob.
15. wit—ab.
16. briskly—at.
17. hall—ob.
18. Orpheus—con.
19. remember—ab.
20. silvery—s.
21. severe—at.
22. come—ob.
23. hard—s. or at.
24. frog—ob.
25. savoursome—s.
26. broadens—ab.
27. olivaceous—ab. or s.
28. culture—ab.
29. courtsy—con.
30. scarlet—s.
31. function—ab.
32. maple—ob.
33. reading—ob.
34. humble—at.
35. carrot—ob.
36. bell—ob.
37. mirrors—ob. or con.
38. braes—con.
39. Hall—ob. or con.
40. comely—at.
41. lake—ob.
42. omnibuses—ob. or con.
43. 1861-62—cn.
44. also—ab.
45. woolly—s.
46. dichotomy—ab.
47. cling— con.
48. majestic—at.
49. medium—ab.
50. paddle—ob.
51. vagrant—con.
52. heterogeneous—ab.
53. clock—ob.
54. dive—ob.
55. tapir—ob.
56. pale—s. or at.
57. myriad—con.
58. spread—ob.
59 murmur—s.
60. gem—ob. or con.
61. streaming—s. or at.
62. inculcate—ab.
63. lapping—s.
64. due—ab.
65. golden—s.
66. jeopardy—con.
67. chattered—con.
68. arcade—ob.
69. low—at.
70. Japanese—at.
71. logical—ab.
72. chink—con.
73. tired—at.
74. eggs—ob.
75. blue—s.
76. analyze—ab.
77. sultry—s.
78. equivalent—ab.
79. sumptuous—at.
80. rhea—ob.
81. bugle—ob.
82. tide—con. or ob.
83. sesquipedalian—ab.
84. grim—at.
85. jingle—s.
86. dusky—s. or at.
87. animated—at.
88. knifeblades—ob.
89. isobar—ab.
90. yes—ab.
91. conterminous—ab.
92. punch—s. or ob.
93. eighty—ab.
94. grate—ob.
95. hyacinth—ob. or con.
96. assimilate—ab.
98. enjoyed—at.
99. incommensurable—ab.
100. gray—s.
101. moist—s.
102. distribute—ab.
103. wended—con.
104. lawns—ob.
105. host—con.
106. bliss—con.
107. dyes—ob.
108. serene—at.
109. turf—con.
110. vast—at.
111. piping—s.
112. extract—ab.
113. cinnamon—s. or ob.

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THE LEARNING CURVE EQUATION

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THE LEARNING CURVE EQUATION

INTRODUCTION

The present investigation is essentially an attempt to devise a statistical method for treating learning data. Part I is a discussion of correlation methods and empirical and rational equations. Part II is a description of the learning curve equation and its interpretation. Part III is a discussion of the application of the learning curve equation to typewriter learning. Part IV is a summary.

Learning curves are usually very erratic and for this reason it is necessary to study the general trend of numerous observations instead of the variable individual observations. The methods to be discussed often make it possible to obtain coefficients which express the characteristics of a subject's learning based on all the observations and in such a manner that all observations are as far as possible equally weighted. Quantitative methods in psychology are far in advance of our control over the things measured, and consequently we make ourselves subject to ridicule when refined correlation statistics are applied to measures which are obviously crude. We shall therefore discuss not only the more refined statistical procedure for the learning curve but also some readily applied methods which are adaptable in the study of more or less erratic learning data. Even though refined technique is available we should select the quantitative methods for any particular study so as to keep a fair balance between the certainty of our measures and the statistical niceties by which we treat them.

For the benefit of any reader who wishes to apply the statistical methods to be described for his own learning data I wish to call attention to the first two sections of the summary in which will be found an outline describing the detailed procedure in calculating the learning coefficients.

In applying these methods of learning curve analysis one should be fully aware of their limitations. They are not applicable to the following conditions of learning: 1) when trial and error learning is mixed with generalizations such as in puzzle solving; 2) when the learning is so erratic that it fails to show continuity; 3) when the learning process has not been carried far enough to reveal the nature of the function; which is often the case with apparently linear learning curves; 4) when the learning curve is not plotted in the speed-amount form; 5) when the learning curve fails to show diminishing returns with practice; 6) when the units of formal practice are variable in the different stages of learning (learning measured on different successive scales can not be treated as a continuous function); 7) when the wrong responses are eliminated by ideational learning without giving any objective scores during the process of elimination. Such learning curves have the same appearance as those which contain generalizations.

1) Verbal Statement of Relationship

Our present problem concerns the relationship between practice and attainment in learning. When an observer notes as an element in common experience that attainment increases as practice increases, he may generalize by verbally asserting a positive relation between the two variables. The verbal generalization is so common that it is embodied in what we call common sense. Thus we expect without further verification that twenty hours of practice in a complex function will yield higher attainment than ten hours of practice under roughly similar conditions, but uncontrolled observation does not tell us how much higher.

2) The Correlation Coefficient as an Expression of Relationship

It is possible to express by a single number the degree of relationship between two variables. This is what one attempts to do by a correlation coefficient. The Pearson coefficient of correlation is so derived that when its value is unity the two variables have perfect concomitance. When its value is —1. the two variables have perfect inverse relationship, a rise in one of the variables being always associated with a proportional decrease in the other. A zero correlation establishes the fact of entire absence of relationship within the conditions of the experiment.

A correlation coefficient considerably less than unity may be explained in at least four different ways: 1) the observations themselves may be so inaccurate as to obscure the relationship; 2) the two variables may be related through a common third variable which, if not controlled or kept constant, plays havoc with the experiment; 3) the regression may be non-linear in which case the Pearson coefficient, r, is almost meaningless;* 4) the two variables may be intrinsically independent. Psychological experimentation rarely yields correlations over 0.85 because of the inaccuracy of psychological measures. When a correlation coefficient turns out to be 0.95 or above an empirical equation may properly be substituted for the correlation methods.

In the interpretation of a correlation coefficient one should be careful to note that while a high correlation coefficient does indicate a relation between the variables under the conditions of the experiment, a low coefficient does not indicate the absence of relationship between the variables. The first, second, or third factors enumerated in the preceding paragraph may be responsible for a low coefficient when a high relation really exists. It is perhaps rare that a correlation is calculated with psychological data which is not grossly affected by all three of these factors.

When one variable is immediately contingent on one or more other variables it is advisable to use the method of partial correlation to establish the relation. Thus the volume of a box is contingent on the three variables, length, width, and depth. Now, if a heterogeneous collection of wooden boxes were to be measured as to all four of these attributes and the correlation coefficient between volume and length determined, it would undoubtedly turn out to be positive and significant because long boxes are usually more voluminous than short boxes. But the

*The term *regression* was introduced by Galton in connection with his statistical studies in the heredity of stature. It is the equation of the best fitting line for a series of paired observations of two variables. The use of the term seems to be restricted to data of considerable dispersion and is not used for those observations in the exact sciences which do not involve serious scatter. The term *linear regression* refers to the equation of a regression line which is straight, as contrasted with *non-linear regressions* which are curved. See Yule, "Textbook in Theory of Statistics," p. 176 and references 2 and 3 on p. 188.

coefficient would not be unity because of the two other variables which were left out of consideration. This would illustrate case 2 in the preceding paragraph. We may distinguish two methods of handling this type of relation. a) We may control the extraneous variables by keeping them constant while measuring the two variables with which we are immediately concerned. This is the customary procedure in the physical sciences. Thus when verifying Boyle's Law we keep the temperature of the gas constant, but when verifying Charles' Law we keep the pressure constant. Except for these precautions neither of the two laws would be observed. In the biological sciences we do not have such ready control over the extraneous variables and the best we can do is to measure them also, while allowing them to vary at will. b) In these cases we use a second method, namely, partial correlation. Thus if we calculate the partial correlation coefficient between volume and length of the collection of wooden boxes, with the depth and width accounted for, we obtain a higher coefficient than when the two extraneous variables were ignored. The advantage of the partial correlation method is that it enables us to control the extraneous variables analytically without having any physical control over them.

There are some limitations of the correlation methods which every experimenter should keep in mind in order to guard against erroneous conclusions. One of the limitations of the partial correlation method is that it assumes the combined effect of the several independent variables on the dependent variable to be additive, a condition which rarely obtains. This limitation is much more serious than the inadequacy of the correlation coefficient for non-linear regressions. A non-linear regression can usually be rectified by one of the algebraic artifices used in connection with empirical equations, but the assumption that the several independent variables produce their effect on the dependent variable in an additive manner can not be handled by any predetermined statistical method. Thus, returning to the box illustration, the best measure we could obtain by the method of partial correlation is expressed in the form

$$v = k_1 d + k_2 w + k_3 l. \tag{1}$$

But the true formula for the volume takes the form

$$v = k.d.w.l. \qquad 2$$

Now, this type of relation is not revealed by the partial correlation method, nor is the method adequate for any of the thousands of ways in which the several variables may combine except the additive one.

If we are not content with merely stating in quantitative form the degree of relationship between the two variables but wish to formulate a method of prediction, we use the regression equation. This equation is derived from the Pearson coefficient which merely states in numerical form the *degree* of relationship between the two variables. It places the information at our immediate command for the purpose of prediction. Given one of the unknowns, the other can be found either from the regression lines or from the regression equation which is simply an algebraic description of the regression line.

It is quite conceivable that a low value of attribute A may be associated with either high or low value of attribute B, whereas a high value of attribute A may be associated with only high values of attribute B. Similarly a low value of attribute B may be associated with low values of attribute A only, whereas high values of B are associated with either high or low values of attribute A. Whenever such conditions obtain the Pearson correlation coefficient is inadequate to express the complete relationship. In these cases, called non-linear regressions, it is advisable to calculate another kind of coefficient which is called the eta coefficient, η,* or correlation ratio. The significance of the correlation ratio may perhaps be made more apparent by the analogue *All dogs are quadrupeds but all quadrupeds are not dogs.* What would correspond to the correlation ratio of dogs on quadrupeds would be very high because all dogs are quadrupeds. But the correlation ratio of quadrupeds on dogs would be low, for only a few of the quadrupeds are dogs. The Pearson correlation coefficient for a relation of this type would be positive but low.

*For a brief statement giving the derivation of the correlation ratio, see Yule, p. 204.

There are a number of algebraic artifices by means of which a non-linear regression may be rectified. The value of such devices becomes apparent when it is considered that such otherwise exceedingly useful tools as are available in the correlation methods are inapplicable as long as the regressions are non-linear. The investigator must rely on his own ingenuity in rectifying a non-linear regression. Some of these methods will be considered in connection with the learning curve equation.

3) Empirical Equations

Every equation can be represented by a line in a diagram and practically every line encountered in quantitative experimental work can be represented by an equation. Thus the regression equation is only an algebraic way of describing the regression line of a scatter diagram, or, putting it the other way, the regression line is a graphical description of the regression equation. Each tells the same story in its respective language.

An empirical equation is an equation selected to fit a given set of data. The observations give us the diagram and if we find an equation whose line coincides with the general trend of the observations, it may be used interchangeably with the diagram for predicting one of the attributes when the other is given. When the observations indicate a linear relation we can derive the corresponding equation with very little trouble, but when the observations fall along a curve and when they are badly scattered the finding of the most representative empirical equation sometimes taxes the investigator's ingenuity. I shall describe the routine steps in determining the empirical equation for a linear relation by means of an example and will show that it turns out to be identical with the regression equation for the same data.

Figure 1 is a diagram of the relation between two hypothetical variables X and Y. Each of the small circles represents a hypothetical observation; the solid line represents the general trend of the observations. This line may be used for the purpose of prediction. Thus if we know that on a certain occasion attribute X had a numerical value of 9, the attribute Y must have been very close to the value 63, as read from the chart. Our problem now is to describe this line algebraically so that the prediction may be made by means of a formula instead of by the diagram.

a) *Method of inspection.* This procedure is the simplest but it can only be applied when the relation is close, as it is in the present illustration. We first indicate the observations by small circles or dots on the diagram. Then we draw by inspection the best fitting straight line through the general trend of the observations. The equation of a straight line always takes the form

$$Y = a + b.X \qquad 3$$

The y-intercept is 30.8 and it is the constant *a*. The slope of the line is 3.56 and it is the constant *b*. Hence the equation for the line is

$$Y = 30.8 + 3.56X \qquad 4$$

This equation may be used interchangeably with the diagram in predicting one of the attributes when the other is known. The procedure is so simple and direct that it would be universally used, were it not for the fact that when the observations scatter badly, it is difficult to draw the best fitting straight line by inspection. Moreover, the same line can not properly be used in predicting X from Y as in predicting Y from X when the data are scattered. In these cases we have recourse to two other types of procedure, namely, the method of the regression equation and the method of least squares.

b) *Method of regression equation.* In figure 2 we have represented a hypothetical set of data which are quite scattered. By the usual correlation methods we obtain the following constants:

$r = + 0.59$
$\sigma_x = 4.58$
$\sigma_y = 3.03$
$n = 50.$
$m_x = 10.$
$m_y = 8.$

The regression equation with two variables for predicting X from Y takes the form

$$x = r_{x,y} \frac{\sigma_x}{\sigma_y} y$$

in which x and y are deviations of X and Y from their respective means. Rewriting this equation in terms of the variables X and Y instead of in terms of the deviations from their means, we have

$$X - m_x = r_{xy} \frac{\sigma_x}{\sigma_y} (Y - m_y) \qquad 6$$

in which m_x and m_y are the arithmetic means of X and Y respectively.

Substituting the numerical values into equation 6 we have

$$X - 10 = \frac{0.59 \times 4.58}{3.03} (Y - 8) \qquad 7$$

and simplifying, we obtain

$$X = 0.89Y + 2.88 \qquad 8$$

This is the regression equation ready for use. By means of it we predict X when the value of Y is known. When the data are not seriously scattered it is safe to fit the line by inspection and determine the empirical equation by the shorter method, but with the data of figure 2 the regression lines can hardly be judged by inspection.

By analogy the regression equation for predicting Y from X takes the form

$$y = r_{xy} \frac{\sigma_y}{\sigma_x} x \qquad 9$$

which when stated in terms of the variables instead of in terms of the deviations from their respective means becomes

$$Y - m_y = r_{xy} \frac{\sigma_y}{\sigma_x} (X - m_x) \qquad 10$$

Substituting and simplifying, as before, we get as a numerical statement of the relation that

$$Y = 0.39X + 4.1 \qquad 11$$

which is ready for use in predicting the most probable value of Y for a known value of X.

These regression equations may be obtained with less arithmetical labor, particularly if only one of the regression equations is needed, by the method of least squares.

c) *Method of least squares.* The method of least squares is an aid in finding the best fitting straight lines for representing a series of observations. It can be applied also to curves but that often leads to awkward mathematical maneuvering. The method of least squares gives a line such that the sum of the squares of the deviations of the independent variable from the regression line is a minimum. It is the best fitting straight line for the observations. The method gives the numerical values of the constants a and b in the equation

$$X = a + b \cdot Y \tag{3}$$

which represents any straight line and by means of which we can predict the most probable value of X from a given value of Y. The application of the method consists in solving the two following formulae:

$$a = \frac{\Sigma(Y)\cdot\Sigma(X\cdot Y) - \Sigma(Y^2)\cdot\Sigma(X)}{[\Sigma(Y)]^2 - n\cdot\Sigma(Y^2)} \tag{12}$$

$$b = \frac{\Sigma(Y)\cdot\Sigma(X) - n\cdot\Sigma(X\cdot Y)}{[\Sigma(Y)]^2 - n\cdot\Sigma(Y^2)} \tag{13}$$

Substituting the appropriate sums from the data we find that $a = 2.9$ and $b = 0.89$. Hence the equation of the best fitting line for predicting X from Y is

$$X = 2.90 + 0.89Y \tag{14}$$

It should be noted that this equation, as determined by the method of least squares, is identical with the regression equation 8 which was determined by correlation methods.

By analogy, the equation for the straight line by which the most probable value of Y may be determined from a known value of X is

$$Y = c + d\cdot X \tag{15}$$

The constants c and d may be determined from the original observations by the formulae:

$$c = \frac{\Sigma(X)\cdot\Sigma(X\cdot Y) - \Sigma(X^2)\cdot\Sigma(Y)}{[\Sigma(X)]^2 - n\cdot\Sigma(X^2)} \tag{15a}$$

$$d = \frac{\Sigma(X)\cdot\Sigma(Y) - n\cdot\Sigma(X\cdot Y)}{[\Sigma(X)]^2 - n\cdot\Sigma(X^2)} \tag{16}$$

Substituting the numerical value of the data from figure 2 into equations 15 and 16 we obtain: $c = 4.09$, and $b = 0.39$. Substituting these numerical values into 15 we get

$$Y = 4.09 + 0.39X \qquad 17$$

by means of which we may predict the most probable value of Y from a known value of X.

It can be shown readily that when the regression equations have been determined by the method of least squares the Pearson coefficient of correlation is expressed by the relation

$$r = \sqrt{b \cdot d} \; * \qquad 18$$

in which *b* and *d* are identical with the regression coefficients.

The above calculations make it apparent that the method of least squares gives us a pair of regression lines which are identical with those obtained by the correlation methods. For the purpose of stating quantitatively the degree of relationship between two variables it is desirable to calculate the correlation coefficient. When the regression equation is of primary interest it can be calculated to advantage by the method of least squares particularly if only one of the regressions is needed.

4) Rational Equations

A rational equation is derived from known relations and is verified by experimental observation. From a philosophic point of view one may argue that all equations used by science are in the last analysis empirical but in practice there is a far cry between fitting an empirical equation to a series of observations and the ability to predict the observed relations on the basis of a rational equation.

Psychology has very few bona fide *laws* on which we can build a system of quantitative prediction and control. Thus practically all we can do with the problem of learning is to observe the function and describe it. The present attempt is to describe it quantitatively by an empirical equation. Some day we shall possess in psychology a coordinated system of really workable concepts with objective reference by which we may be able to predict and control at least certain aspects of behavior by rational equations or their equivalents.

*See Yule, p. 203.

II. THE LEARNING CURVE EQUATION

1) Purpose of the Equation

When the learning function for a simple coordination proceeds undisturbed by external or internal distraction it usually follows a law of diminishing returns. In the majority of learning curves the amount of attainment gained per unit of practice decreases as practice increases. Exceptions to this tendency are found in studying the learning of complex processes such as a foreign language, and when successive generalizations are involved such as puzzle solving and the like. These exceptions sometimes take the form of a positive acceleration at the initial stage of the learning, plateaus during the course of learning and erratic advance of attainment. But these irregularities should not stand in the way of an attempt to express the learning function as a law provided that we do it with due conservatism in its interpretation. All we can hope to do in thus expressing the learning function is to formulate what can with considerable certainty be considered as the typical relation between practice and attainment.

Besides giving the satisfaction of formulating the relation between practice and attainment, the use of an equation for this relation enables one to predict the limit of practice before it has been attained, provided that the learning follows the law of diminishing returns. It also enables one to differentiate for various purposes the rate of learning from the limit of practice since these two attributes are undoubtedly independent. It enables us to state how much preceding practice the subject has experienced under the assumption that the learning function followed the same law before and after the formal measurements. Another use for which the equation can be of service is in the analysis of the relation between the variability in learning and other mental attributes. The problems of formal discipline may be investigated by ascertaining whether a succession of learning processes, all of the same type, yields any rise in the limit of practice, or a higher rate of learning, or a greater consistency of learning in the successive learning processes. Some of these coefficients may be more susceptible than others to modification by successive repetition of the same type of learning. This would in reality be studying the problems of learning how to learn. All questions of transfer of training may be investigated by the learning equation and the transfer effect may be differentiated into its psychological components. Thus, continued practice in learning poetry may show no rise of the practice limit, but a considerable rise in the rate at which that limit is approached and in a decrease of the variability of the learning. Relearning may be found to approach the same limit of practice as the initial learning but it may proceed at a higher rate, and this rate can be stated as a coefficient which is independent of the amount of previous practice in each learning process. The laws of forgetting are expressible in terms quite similar to those here used for the learning function. It is not at all unlikely that these coefficients may come to be significant in individual psychology quite apart from their immediate utility as descriptive attributes of the learning function. The preceding remarks have, I hope, justified my attempt to devise a method for investigating the learning, memory, and forgetting functions.

2) The Equation

After experimenting with some forty different equations on published learning curves I have selected a form of the hyperbola as being for practical purposes the most available. It takes the form

$$Y = \frac{L \cdot X}{X + R} \qquad 19$$

in which

Y = *attainment* in terms of the number of successful acts per unit time.

X = *formal practice* in terms of the total number of practice acts since the beginning of formal practice.

L = *Limit of practice* in terms of attainment units.

R = *Rate of learning* which indicates the relative rapidity with which the limit of practice is being approached. It is numerically high for a low rate of approach and numerically low for a high rate of approach.

Equation 19 represents a learning curve which passes through the origin, i.e., it starts with a zero score at zero formal practice. The majority of learning curves start with some finite score even at the initial performance. For learning curves which do not pass through the origin, the equation becomes

$$Y = \frac{L(X+P)}{(X+P)+R} \qquad 20$$

in which P = ***equivalent previous practice*** in terms of formal practice units.

Figure 3 represents the learning curve for subject No. 23 in the group of fifty-one typewriter students to be discussed in a later section. This curve is plotted between attainment, Y, in terms of the number of words written in a four minute test given weekly for seven months, and formal practice (X) in terms of the total number of pages written since entering the course. We shall call this type of curve the ***speed-amount*** curve to distinguish it from other ways of plotting the same data.

Equation 19 may be rectified as follows:

$$Y = \frac{L \cdot X}{X + R}$$

$$XY + R \cdot Y = LX$$

$$X + R = L\left(\frac{X}{Y}\right) \qquad 21$$

This equation is linear if X/Y is plotted against X. Similarly equation 21 may be rectified when written in the form

$$X + (R + P) = L\frac{(X + P)}{Y} \qquad 22$$

which becomes linear when $(X + P)/Y$ is plotted against X.

When so rectified, the constants L, R, and P may be determined by several different methods, the choice between which depends on the scatter of the data, the desired accuracy, and the number of curves one has to calculate. We shall describe four methods of calculating the coefficients.

a) *Method of least squares*

Case 1: when the learning curve passes through the origin: Arrange the data as in table 1. Calculate X/Y and tabulate. Plot X/Y against X as in figure 4. For convenience we shall call

$$\frac{X}{Y} = Z \tag{23}$$

The reader will notice that the learning data as plotted in figure 4 falls practically in a straight line whereas the same data in figure 3 takes the typical learning curve form.

The equation for the best fitting straight line of figure 4 can be represented by the equation

$$Z = c + d \cdot X \tag{24}$$

The constants *c* and *d* are determined from the table of data by the formulae:

$$c = \frac{\Sigma(X) \cdot \Sigma(X \cdot Z) - \Sigma(X^2) \cdot \Sigma(Z)}{[\Sigma(X)]^2 - n \cdot \Sigma(X^2)} \tag{25}$$

$$d = \frac{\Sigma(X) \cdot \Sigma(Z) - n \cdot \Sigma(X \cdot Z)}{[\Sigma(X)]^2 - n \cdot \Sigma(X^2)} \tag{26}$$

which are simply the least square formulae (15) and (16) re-written for X and Z. Substituting the proper sums, we have $c = 0.42$, and $d = 0.0041$. Hence the equation for X and Z becomes

$$Z = 0.42 + 0.0041X \tag{27}$$

which by replacing X/Y for Z and transposing becomes

$$Y = \frac{244X}{X + 102} \tag{28}$$

in which the predicted limit of practice, L, is 244 words in four minutes, and the rate of learning, R, is 102. The constants L and R may also be determined by the relations

$R = c/d$

$Z = 1/d$

Plotting equation (28) we obtain the solid line in figure 3. It will be noticed that this curve fits quite well the general trend of the observations which are indicated by the small circles. This method of stating algebraically the relation between practice and attainment is of course not applicable unless the speed-amount curve for the data takes the typical hyperbolic form.

Case 2: when the learning curve does not pass through the origin. When the learning curve does not pass through the origin it can be rectified by slightly different procedure. We shall take as an illustration the combined curve for a group of fifty-one subjects studying typewriting. Figure 5 represents the average speed of typewriting against the total number of pages written since entering the course. It is seen to be a fairly smooth and regular curve.

The equation for the learning curve which does not pass through the origin is

$$Y = \frac{L(X + P)}{(X + P) + R} \tag{20}$$

or, if we call

$$P + R = K \tag{32}$$

for convenience, we have, instead of equation (20)

$$Y = \frac{L(X + P)}{X + K} \tag{33}$$

This equation can be rectified as follows: When $X = 0$, and $Y = Y_1$, Y_1 being the initial attainment score,

$$Y_1 = \frac{L \cdot P}{K} \tag{34}$$

and hence equation (33) becomes

$$\frac{X \cdot Y}{Y - Y_1} = L \frac{X}{Y - Y_1} - K \tag{35}$$

This equation is linear if $XY/(Y—Y_1)$ is plotted against $X/(Y—Y_1)$, in which case L is the multiplying constant and K is the additive constant.

Plotting the data represented in figure 5 in this manner we obtain figure 6 in which the learning data appear as a straight line. This line may be represented by the equation

$$S = a + b \cdot T \tag{36}$$

in which

$$T = \frac{X}{Y - Y_1} \text{ and } S = \frac{X \cdot Y}{Y - Y_1}$$

The numerical values of *a* and *b* may be determined by the following least square formulae which are identical with equations *12* and *13*, except for the analogous notation.

$$a = \frac{\Sigma(T)\cdot\Sigma(S\cdot T) - \Sigma(T^2)\cdot\Sigma(S)}{[\Sigma(T)]^2 - n\cdot\Sigma(T^2)} \qquad 37$$

$$b = \frac{\Sigma(T)\cdot\Sigma(S) - n\cdot\Sigma(S\cdot T)}{[\Sigma(T)]^2 - n\cdot\Sigma(T^2)} \qquad 38$$

Substituting the proper sums we find that $a = -148.$ and $b = 216.$ Hence

$$S = 148. + 216.T \qquad 39$$

which is the equation of the solid line in figure 6. This equation may be transposed into the original form of equation *20*, or we may write it in that form directly by the following relations:

$$a = K$$
$$b = L$$
$$P = \frac{a\cdot Y_1}{L}$$
$$R = K - P$$

All of the constants K, L, Y, P, and R, are positive when applied to learning curves. It should be noted that Y_1 is a representative original score determined by projecting the learning curve back to the y-axis. In figure 5 the actually observed initial score was used since it is continuous with the rest of the data. But it is occasionally necessary to select a representative initial score since Y_1 is weighted in this procedure more than any of the other points. The numerical values of these constants for the data of figure 5 are as follows:

$$L = 216.$$
$$P = 19.$$
$$R = 133.$$

Substituting these constants in equation *33* we have

$$Y = \frac{216.(X + 19.)}{X + 148.} \qquad 40$$

which when plotted becomes the solid line of figure 5. The reader will notice that this equation, as represented by the solid line in figure 5, is a beautiful fit for the data, and it justifies our use of equations *19* and *20* to represent the hyperbolic form of learning curve.

The predicted limit of practice L which is 216. words in four minutes, is of course based on the assumption that the learning curve would continue as uniformly beyond the measurements as it did during the measurements. This limitation must be kept in mind and we shall therefore differentiate between the predicted limit and a limit of practice which has been practically attained. The equivalent previous practice (P) is *19* pages which we may interpret as the average number of pages of typewriting to which the previous general experience of our subjects was equivalent. This interpretation of the constant P is also limited by the assumption that the unmeasured learning function followed the law which the measurements reveal. One circumstance which bears out this assumption is that those learning curves which actually do pass through the origin and which do not show positive acceleration usually follow this curve law when the coordinates are properly chosen. The curve of figure 5 does not pass through the origin but this is explainable by the fact that a person who has never touched a typewriter will in four minutes make some finite score even though handicapped by using *the hunt and punch method.*

b) *Method of inspection*

When the observations fall very nearly in a straight line as they do in figure 6 it is hardly necessary to plough through the arithmetical labor involved in evaluating the constants a and b of equation *36* by the method of least squares unless one has ready access to a calculating machine. After plotting figure 6 one may draw at sight the best fitting straight line through the general trend of the data and evaluate the constants from any of the following relations:

$$\text{y-intercept} = a = K$$

$$\text{x-intercept} = K/Y_1$$

$$\text{slope} = L$$

$$P = \frac{a \cdot Y_1}{L}$$

$$R = K - P$$

By this graphical procedure much labor is saved in calculating the learning curve constants and the method is identical with the preceding in principle.

c) *Method of three equidistant points*

The learning coefficients may be determined from three selected points with less labor than when all the observations are taken into account. These three points should be so selected that they represent the general trend of the learning curve.

Let the three selected points be denoted X_1Y_1; X_2Y_2; and X_3Y_3. Let X_1 be zero, X_3 the total amount of practice and X_2 the midpoint between X_1 and X_3. Let the Y-values be the most representative ordinates to the curve. Then

$$X_3 = 2 \cdot X_2 \qquad 41$$

By substituting these values into equation *20*, transposing and simplifying, we obtain

$$K = \frac{X_3(Y_2 - X_3)}{Y_3 + Y_1 - 2Y_2} \qquad 42$$

$$L = \frac{Y_3(X_3 + K) - Y_1 \cdot K}{X_3} \qquad 43$$

$$P = \frac{Y_1 \cdot K}{L} \qquad 44$$

$$R = K - P \qquad 45$$

From these relations we may determine the numerical values of the learning coefficients in terms of the three equidistant points.

When the curve passes through the origin both X_1 and Y_1 are zero. The coefficients may then be determined by the following somewhat simpler relations:

$$K = \frac{X_3(Y_2 - Y_3)}{Y_3 - 2 \cdot Y_2} \qquad 46$$

$$L = \frac{Y_3(X_3 + K)}{X_3} \qquad 47$$

$$R = K$$

P is zero because when the initial score is zero the equivalent previous practice is zero.

3) Interpretation of Learning Constants

We have seen that the learning curve equation *20* fits very well the learning data to which we have applied it. In order to bring out the interpretation of the learning coefficients we shall compare several learning curves with high and low numerical values of the coefficients.

In figure *7* we have two hypothetical learning curves with different physiological limits but with identical rates of approach. Figure 8 represents two hypothetical learning curves, both approaching the same limit of practice, one at a high rate and the other at a low rate. Figure 9 represents two hypothetical learning curves with same limit of practice, and with the same rate of approach, but differing in the amount of previous practice. Curve A represents forty units of previous practice while curve B represents no previous practice. The two curves are identical in shape, the only difference between them being that curve B is forty x-units to the right of curve A. The same interpretation would be reached if the two curves were superimposed and the formal practice measurements started at the origin for curve B and after forty practice units for A.

4) The Coordinates for Learning Curves

So far we have considered learning curves plotted only between the coordinates X (total number of practice acts since the beginning of practice) and Y (the number of successful acts per unit time). Learning curves have, however, been plotted with various units for the coordinates and we shall consider several of these together with some inferences that may be drawn from the translation of learning data from one system of units to another.

The speed-amount curve is the name we shall use to designate the form of learning curve we have been considering. It is plotted as speed, Y, against amount of practice, X. It may be represented by equations 19 and 20 when it reveals the typical hyperbolic form.

The time-amount curve is plotted as time, t, per unit amount of work against total amount of work, X, since the beginning of practice. It is evident that the ordinates of this type of curve will be proportional to the reciprocals of the speed-amount curve for the same data. Hence we may define *t* as

$$t = \frac{C}{Y} \qquad 48$$

where *t* is the time per unit amount of work and *C* is a constant. Limiting ourselves to the curves of diminishing returns we have, as the equation of the time-amount curve

$$t = \frac{C(X + K)}{L(X + P)} \qquad 49$$

The constant *C* is only significant in translating learning curves from one form to the other. Applying the equation directly to learning data the constant *C* may be dropped. In that case

$$t = \frac{X + R}{L(X + P)} \qquad 50$$

This equation may be rectified by the procedure previously outlined for equations *19* and *20*. When $P = \text{zero}$, we have

$$t = \frac{X + R}{L \cdot X} \qquad 51$$

which can be rectified by plotting tX against X.

In order to determine whether equations *50* and *51* really fit the time-amount curve throughout its range I have given a long substitution test to one of my students. He took the test seventeen times, once a day, and reached what is for all practical purposes a practice limit. The time-amount curve for this learning test is represented in figure 11. In figure 12 I have rectified the data by plotting the products tX against X. The reader will notice that the speed-amount curve is hyperbolic. It is quite gratifying that the learning records for an individual subject follow the hyperbolic law so closely. In order to avoid erratic scores from individual subjects it is absolutely essential that they work under uniform conditions with a minimum amount of distraction. The student whose substitution learning is represented in figures 11 and 12 took the test once a day only and always at 1 P. M. The test consisted in making six hundred substitutions at each sitting.

The time-time curve is the learning curve plotted between the time, t, per unit amount of work and the total time, T, devoted to practice. An empirical equation may be derived for this type of curve from the assumed hyperbolic form of the speed-amount curve. The total time is the summation $\Sigma t \cdot dx$ for the whole period of learning. Hence

$$T = \int t \cdot dx \qquad 52$$

But from equation *50*

$$t = \frac{X + K}{L(X + P)} \qquad 50$$

and hence

$$T = \int \frac{X + K}{L(X + P)} dX$$

which may be written

$$T = \frac{1}{L} \int dX + \frac{K - P}{L} \int \frac{dX}{X + P}$$

Integrating, we obtain

$$T = \frac{X}{L} + \frac{K - P}{L} \log (X + P) + C_1 \qquad 53$$

which gives the equivalent total time T in terms of X. Stating X explicitly from equation *50* and substituting in equation *53* gives the desired relation between T and t as

$$T = \frac{K - t \cdot L \cdot P}{(L \cdot t - 1)L} + \frac{K - P}{L} \log \left(\frac{K - P}{L \cdot t - 1}\right) + C_2 \qquad 54$$

While this equation does give us a relation between T and t as derived from the hyperbolic speed-amount curve it is too unwieldy to be practically feasible. We are hardly justified in using so complex an empirical equation for learning data.

The speed-time curve is plotted between the speed Y (number of successful acts per unit time) and the total amount of time, T, devoted to practice. An equation between Y and T may be derived by stating X explicitly from equation *20* in terms of Y and substituting this for X in equation *53* which gives

$$T = \frac{P - K}{Y - L} + \frac{K - P}{L} \log Y - \frac{K - P}{L} \log (L - Y) + C_2 \quad 55$$

While this equation is too cumbersome for extensive use it serves one very interesting function in that it sheds light on the question of positive acceleration in learning curves.

5) Initial Positive Acceleration in the Speed-Time Curve

Equation 55 represents the speed-time curve. It may be simplified by letting

$$A = P - K \text{ and } B = \frac{K - P}{L} \quad 55a$$

when it becomes

$$T = \frac{A}{Y - L} + B \cdot \log Y - B \cdot \log (L - Y) + C_2 \quad 56$$

The first derivative with respect to Y is

$$\frac{dT}{dY} = - \frac{A}{(Y - L)^2} + \frac{B}{Y} + \frac{B}{L - Y} \quad 57$$

The second derivative is

$$\frac{d^2T}{dY^2} = \frac{2A}{(Y - L)^3} - \frac{B}{Y^2} + \frac{B}{(L - Y)^2} \quad 58$$

which when simplified becomes

$$\frac{d^2T}{dY^2} = \frac{B \cdot (L)^2 \cdot (3 \cdot Y - L)}{Y^2 \cdot (L - Y)^3} \quad 59$$

since $A = - BL$ from equation 55a

Equating the second derivative to zero, we have:

$$\frac{B \cdot (L)^2 \cdot (3 \cdot Y - L)}{Y^2 \cdot (L - Y)^3} = 0$$

which is true when Y has the value L/3.

This demonstrates the presence of a point of inflection in equation 55 at the value L/3 for Y. The psychological significance of this relation may be stated as follows:

The learning curve in the speed-time form must necessarily have an initial positive acceleration which changes to a negative acceleration when the attainment has reached one-third of the limit of practice. This conclusion is contingent on the assump-

tion that the learning curve in the speed-amount form is hyperbolic, an assumption which has been empirically shown to be safe for the majority of learning curves. As has already been said, the speed-amount curve is usually hyperbolic but not always. These assertions regarding the speed-time curve are not applicable when the speed-amount curve for the same data is not hyperbolic. The positive acceleration can not, of course, be obtained when the initial score is greater than one-third of the practice limit. It can only be observed when the initial score is less than one-third of the practice limit.

In order to test empirically the above finding with regard to initial positive acceleration I have plotted in figure 13 the average typewriting speed for fifty-one subjects against weeks of practice (the speed-time curve) instead of against total number of pages written (the speed-amount curve). The average practice limit for this group has already been found to be 216 words in four minutes according to the speed-amount curve for the same data. The reader will notice the initial positive acceleration followed by negative acceleration, and also that the point of transition from positive to negative acceleration takes place at a writing speed of about seventy words in four minutes, as it should do according to our analysis of the speed-time curve. If this finding will stand the test of further experimentation it is obviously of considerable diagnostic value for the psychologist who can by means of it predict the practice limit when attainment reaches one-third of its limit. The limitation in the use of this relation is mainly in the erratic improvement in complex coordinations which are learned under variable conditions of distraction and in the occasional deviations from the typical hyperbolic form of the speed-amount curve.

6) Other Possible Equations

Before closing the discussion on the learning curve equation as such it might not be out of place to mention a few of the other equations which I have tried to use for learning data. These will not be of interest to the general reader but may be of interest to those who wish to try their hand at other empirical equations for the learning function.

One of these equations for the speed-amount curve is

$$Y = L[1 - \frac{1}{e^{aX}}] \qquad 60$$

where e is the Naperian base or some other constant. This equation can not readily be rectified except by trying successive values for L. When the proper value for L is found it can be rectified when written in the form

$$\log (L - Y) = \log L - a \cdot X \cdot \log e \qquad 61$$

by plotting $\log(L-Y)$ against X. If the curve does not pass through the origin equation *60* becomes

$$Y = L[1 - \frac{1}{e^{a(X+P)}}] \qquad 62$$

which is rectified if the proper numerical values of L and P are found by writing it in the form

$$\log(L-Y) = \log L - a(X+P)\log e \qquad 63$$

and plotting $\log(L-Y)$ against $(X+P)$. This equation gives a fair approximation to the speed-amount curve but it does not fit nearly as well as the hyperbolic form previously considered. It can be rectified graphically by plotting Y-increments against X but this procedure is not feasible unless the individual observations are more consistent than they usually are for learning data. The constants L and P can also be determined graphically from three selected points. If X_1Y_1, X_2Y_2, and X_3Y_3 be three points on the curve, equidistant on the axis of abscissae, then the two lines X_3Y_2; X_2Y_1 and X_3Y_3; X_2Y_2 will intersect in a point which is on the asymptote parallel to the axis of abscissae, thus determining the constant L graphically. This equation gives a fair approximation to the speed-amount curve but it does not fit nearly as well as the hyperbolic form previously considered.

Another equation which gives a fair approximation to the learning curve is

$$Y = L(B^{-\frac{C}{X}}) \qquad 64$$

in which B and C are constants. It can be rectified by writing it in the form

$$\log Y = \log L - \frac{C}{X} \log B \qquad 65$$

and plotting logY against 1/X. It has the advantage of simplicity and it can be used to represent an initial positive acceleration. But as far as I have been able to determine the constant L does not agree as well with observed values as the hyperbolic form.

One could perhaps write an indefinite number of exponential, trigonometric and other functions to represent the learning curve but as long as the simple equation *20* with its various transformations fits the data, and as long as we do not have the basis for a rational equation for learning I have been content to abide by it.

TYPEWRITER LEARNING

1) The Subjects

Eighty-three students at the Duff Business School in Pittsburgh took one four minute typewriter test once a week during the school year 1916-17. The tests were begun in September and continued until the middle of April. The subjects practiced two hours of school schedule time every day, five days a week. No tests are available for the first three weeks of practice because teachers of typewriting who use the touch system prefer not to give tests from straight copy until the mechanism of the typewriter and the key board have been mastered. This takes from three to seven weeks, depending on the maturity, adaptability and industry of the students. Practically all of the subjects had finished the grammar school, a number of them had completed one or two years of high school, and several had finished a four year high school course. Their average age was about seventeen years. In order to obtain an initial typewriting score I asked ten of my students who had never touched a typewriter to take a four-minute test. The average score for this group was 27 words in four minutes and this is used with the other data as an average initial score in typewriting.

Of the eighty-three subjects who took the tests thirty-two were eliminated, leaving fifty-one subjects for the major study. The causes of elimination are indicated in the following table:

Original size of group.........		83
Irregular attendance	20	
Unusually irregular performance	3	
Apparent linearity of learning curve	5	
Delayed positive acceleration....	2	
Demonstrable plateau	2	
Total eliminated		32
Size of group for major study...		51

The twenty subjects eliminated from the major study on account of irregular attendance are not of interest in this connection. Three subjects were eliminated for extremely erratic performance in the tests. It is impossible that their real typewriting ability is even approximately represented by their erratic scores. The cause for their variability is undoubtedly due to lack of consistent interest in their work and in the tests. Most of the subjects took a competitive attitude toward the tests, the results of which were given them weekly by their instructor.

Ten subjects had learning curves which deviated from the typical hyperbolic form which we are here considering. This is a limitation of our method which is only applicable to the hyperbolic form of the speed-amount curve. Of these ten subjects five were eliminated from the major study on account of apparent linearity of the learning curves. *No learning curve can ever be continuously linear if it is plotted in the speed-amount form.* If it were linear the subject would have no physiological limit and he would in time reach the rather enviable attainment of infinite writing speed, which is of course absurd. Another alternative with a linear learning curve is that it is linear until it reaches the practice limit after which it remains at the limit. I can not entertain this as a possibility for it is inconceivable that an organic function like learning proceeds according to a linear relation until it bumps into some inflexible practice limit at which it stops and remains. The only possible explanation of apparently linear learning curves that I am willing to entertain is that they are in reality curved but that the degree of curvature is so small that it is concealed by the variability of the individual observations. Such learning curves are therefore indeterminate unless they be continued far enough to make the curvature appear in spite of the variations of the individual observations. This leads to the conclusion that the accuracy with which the learning coefficients can be determined is contingent on two principal factors. It varies a) with the degree of curvature of the learning curve, and b) inversely as the variability of the individual measurements. The coefficients of a learning curve with minimum variability may be determined with a minimum amount of visible curvature. The more variable the measurements the greater is the degree of curvature necessary for a fairly accurate determination of th learning curve coefficients. Whether the linearity of the curves of these five subjects is apparent or real can not be settled with the available data. If the linearity is real it constitutes a limitation in the use of the learning curve equation.

Two subjects were eliminated on account of delayed positive acceleration. Their learning curves constitute deviations from the usual shape of curve and can not be handled by the methods which we are discussing here. It is not certain that these measures are not simply cases of erratic performance.

Two out of the eighty-three subjects showed clear evidence of a plateau. Whether this is psychologically significant or simply due to the fact that these subjects were offered positions after attaining a specified typewriter proficiency is indeterminable. The higher order learning curve which followed the first curve is not carried far enough with either of these two subjects to justify determining the learning coefficients for the first and second order curves.

We have eliminated twelve out of sixty-three complete records. Generalizing from this fact we may conclude that the speed-amount form of learning for typewriting takes the hyperbolic form in about four cases out of five. This justifies our reference to it as the typical but not as the universal form of learning curve.

2) The Coordinates of Curves for Typewriting

My first intention was to plot the learning curves with speed as ordinates and time in weeks as abscissae, the speed-time form. Finding that the industry of the subjects during the practice hours varied immensely I decided that the psychological analysis would be more equitable if I measured practice in terms of total number of pages written rather than in terms of time, although time is statistically more readily obtained than the amount of practice. The practice sheets were all turned in to the teacher in charge who tabulated every week the number of pages written by each subject. According to the typewriter championship rules, attainment should be scored by deducing five words from the speed total for every error. For the purpose of psychological study I have separated errors from speed. The learning curves are all plotted as speed (words in four minutes; disregarding errors) against formal practice (pages written since entering the course). While errors are entirely disregarded in these curves the subjects were of course not informed on this point. The errors are studied separately by correlating them with the other learning characteristics. In this manner we shall arrive at a statement of the relationship between the several learning characteristics without artificially loading them with each other, as would be the case if we penalized the score for speed by the number of errors.

3) The Learning Coefficients for Typewriting

We shall use the following notation in studying typewriter learning.

X = *Practice,* in terms of the total number of pages written since entering the course.

Y = *Attainment,* in terms of the number of words written in four minutes.

x = Number of pages written when an individual test is taken.

y = Number of words written in a four minute test. It is the observed speed whereas Y is the speed indicated by the learning curve equation.

n = Number of tests taken.

y_a = Average speed in all tests or

$$y_a = \frac{\Sigma y}{n}$$

y_{20} = Average speed after twenty weeks of practice, and similar notation for the average speed at other stages of learning.

L = *Predicted practice limit* in terms of words written in four minutes.

R = *The rate of learning,* a constant which is numerically large for a low rate of approach and numerically low for a rapid rate of approach.

P = *Equivalent previous practice* in terms of practice units (pages written). It is the negative x-intercept of the speed-amount curve.

d = ***Absolute deviation*** which expresses the deviation of any single observation above or below the value indicated by the learning curve at that stage of learning. It is positive when the speed of any single test is above that indicated by the learning curve, and negative when the actual speed is below the learning curve. It can also be represented by the relation

$$d = y - Y$$

D = ***Average deviation*** for all tests during the year, or

$$D = \frac{\Sigma d}{n}$$

d_r = ***Relative deviation*** of an individual test, determined by the ratio

$$d_r = \frac{d}{Y} = \frac{y - Y}{Y}.$$

D_r = ***Average relative deviation,*** determined by the ratio

$$D_r = \frac{\Sigma(d_r)}{n}$$

V = ***Coefficient of variability,*** determined by the ratio

$$V = \frac{D}{y_a}$$

e = ***Number of errors*** made in an individual test as determined by the Typewriter Championship rules.

E = ***Average number of errors*** in all tests, or

$$E = \frac{\Sigma(e)}{n}$$

e_r = ***Relative inaccuracy*** of an individual test, or

$$e_r = \frac{e}{y}$$

E_r = ***Average relative inaccuracy*** for all tests, or

$$E_r = \frac{\Sigma(e_r)}{n}$$

A = ***Coefficient of inaccuracy,*** determined by the ratio

$$A = \frac{E}{y_a}$$

4) FINDINGS

a) *Writing Speed*

Figure 5 indicates the relation between average speed and number of pages practiced. The law of diminishing returns is shown by the continuity of the points representing average speed but we can not assert the universality of this form because we have already eliminated 12 out of the 63 available records. It will serve well as a norm of average performance for groups comparable with the one here represented. It is interesting to note that the curve does not pass through the origin. This is explainable by the fact that a person who has never written on a typewriter can, nevertheless, even on the first trial, make some finite score. I could not readily obtain a test from the fifty-one subjects prior to formal instruction on the typewriter. In order to ascertain what a truly initial score is, I asked ten of my students who had never touched a typewriter to take a four minute test. The mean as well as the average of these ten subjects was 27 words in four minutes. This is the point to which the composite learning curve in figure 5 projects.

The solid line of figure 5 represents the hyperbolic curve form. It is a good fit on the data which are represented by the small circles. The equation of the composite curve is

$$Y = \frac{216.(X+19.)}{X+148.} \qquad 40$$

in which Y is the average score for the 51 subjects and X is the number of pages of practice. The predicted limit of practice for speed is 216. words in four minutes, which agrees well with average typewriter speed. The average of the limits of practice as determined from the individual curves is 214. The equivalent previous practice for the composite curve is 19. This indicates that the general experience which these subjects brought to their first practice on the typewriter was equivalent to nineteen pages of formal practice. The rate of learning, R, for the composite curve is 129, a constant which varies inversely with the relative rapidity with which the limit of practice is approached. The average of the rates of approach as determined from the individual curves is 137. The composite curve, figure 13, is plotted against time in weeks instead of against amount of practice. It has an entirely different appearance. It shows the initial positive acceleration previously discussed.

We shall now turn to the individual records and ascertain by correlation methods the interrelations of the learning characteristics for typewriting.

The correlation between the predicted limit of practice and the average speed of writing for all tests during the year is 0.68. This correlation could not even theoretically be close to unity for while the fast writers tend to approach the higher practice limits there is considerable variation in the rate at which the limit is approached. It should be noted that the predicted limit was not attained by these subjects. The limit is predicted on the basis of the curve shape. If the predicted limit used here agrees at all closely with the ultimate writing speed of these subjects, the correlation of 0.68 between the practice limit and the average writing speed during eight months' instruction indicates that the latter measure is not a very reliable criterion of ultimate proficiency. I think that it constitutes another piece of evidence against hasty and self-confident predictions based on so called vocational mental tests.

The correlation between the predicted limit of practice, L, and the rate of learning, R, is 0.75. This indicates that those who approach a high limit of practice in speed generally approach their limit at a lower rate than those who are approaching a low speed as their limit. The regression is linear and hence the converse is true, namely that those who approach a low limit of practice generally approach their limit at a relatively higher rate than those who have a high limit of practice.

The correlation between predicted limit of writing speed and average number of errors in unit time is 0.10. Hence we conclude there is no discernible relation between the normal writing speed and the absolute number of errors made per unit time. But there is a noticeable relation between the coefficient of inaccuracy, A, and the practice limit, L. The coefficient of correlation is only —0.16 but the regression is non-linear. Those who approach a low practice limit for writing speed tend to be inaccurate, but those who approach a high practice limit are either accurate or inaccurate. On the other hand those who are unusually accurate tend to be fast writers whereas those who are inaccurate are either fast or slow writers. The number of subjects is not large enough to warrant the calculation of the eta coefficient.

The correlation between the predicted writing speed and the speed after eight weeks of practice is 0.27. Making use of the actual data instead of predicted performance, we find that the correlation between the speed after eight weeks practice and that after twenty weeks practice is 0.74. The correlation between predicted limit and the average writing speed for all tests is 0.68.

In this connection I wish to suggest what will perhaps be a more reliable technique in psychological prognosis. If a high degree of relationship can be established between the learning curve constants for a complex function, performance in which is to be predicted, and the corresponding constants for a simple learning function which can be completed during a single sitting, then the constants for the simple learning test would have diagnostic value in predicting performance in the complex function. Such coefficients would not be subject to the accidents of a first performance but would represent the organically more significant learning function as such. The diagnostic value of such a technique is largely dependent on the degree of difficulty of the material to be learned.

b) *The errors*

The relation between the average absolute number of errors made in each test and the number of weeks of practice is indicated in figure 16. This shows that the number of errors in unit time increases with practice. The relation between these two attributes may be expressed by the empirical equation

$$e = 0.12T + 2.1 \qquad 66$$

in which e is the average number of errors in a four minute test, and T is the number of weeks of instruction. The equation expresses a norm of average performance.

The analogous relation between average absolute number of errors and writing speed during the year is shown in figure 17.

This also indicates that the number of errors made in unit time increases with the attainment of writing speed. The relation may be expressed by the empirical equation

$$e = 0.023y + 1.5 \qquad 67$$

which is fairly representative within the limits of observation. However, the relative inaccuracy decreases with practice as indicated in figure 18, i.e., the number of errors per page decreases with practice but the number of errors per unit time increases with practice. There is no discernible relation between the relative inaccuracy (errors per unit time) and the rate of learning.

c) The variability

Those who have a high practice limit for writing speed usually have a larger average deviation from their learning curves than those who approach a low practice limit. This statement must be considered in connection with relation between predicted limit of writing speed and the average *relative* deviation. The correlation between predicted writing speed and average relative deviation for all tests is 0.27, indicating that the fast writers have a slight tendency to be more erratic in speed than the slow writers, even though the measure of variability is taken as the ratio of deviation to writing speed. According to this measure the writer of 60 words per minute is allowed a deviation from his representative learning curve twice that of a writer of 30 words per minute. But even according to this relative standard of variability the fast writers tend to be slightly more erratic in speed.

Figure 14 indicates that the deviations from the learning curve increase with practice but figure 15 shows that the ratio of deviation to theoretical writing speed, as indicated by the curve, decreases with practice. It is apparent that, just as one would expect, the absolute deviations increase with practice but the relative deviations decrease with practice. The decrease in the relative deviation with practice does not become noticeable until after about three months but after that the relation is approximately linear with practice time. In other words, the variability of the writing speed for any individual subject tends to decrease with practice, but if he is a fast writer he tends to be more variable in his writing speed than if he is a slow writer, even when the variability is measured in relative terms.

SUMMARY

1) Forms of the Learning Curve

We have discussed four different forms in which most learning data can be graphed. We have called these forms 1) the *speed-amount* curve, 2) the *speed-time* curve, 3) the *time-time* curve, and 4) the *time-amount* curve.

The *speed-amount* curve is plotted as speed, number of successful acts per unit time, or a multiple thereof, against the total number of formal practice acts, or some multiple of it. In plotting typewriter learning we have used words in four minutes, and the total number of pages written as the coordinates of the speed-amount curve. This form of curve is illustrated in figure 5 which gives average writing speed for fifty-one subjects against total number of pages written. The small circles indicate the observations and the solid line indicates the general trend of the learning. The solid line is represented by the general equation

$$Y = \frac{L(X+P)}{(X+P)+R} \qquad 20$$

in which

$L =$ Predicted practice limit in terms of speed units.
$X =$ Pages written.
$Y =$ Writing speed in terms of words in four minutes.
$P =$ Equivalent previous practice in terms of pages.
$R =$ Rate of learning, a constant which varies inversely as the relative rapidity with which the practice limit is being approached.
$K = P + R$, a constant used for convenience.

The particular line of figure 5 is represented by the equation

$$Y = \frac{216.(X+19.)}{X+148.}$$

which we may interpret as follows. The predicted average practice limit, L, for the group of fifty-one subjects is 216 words in four minutes or about 54 words a minute. The rate of learning, R, is a constant which in this curve has the value of 129.

Its only usefulness is in comparing the rates of several learning curves with each other. By itself, and for a single curve, it has no significance. When used to compare several learning curves the precaution must be observed that all curves so compared be plotted by the same units for the coordinates. The equivalent previous practice is nineteen pages. This is interpreted to mean that the general experience which these students brought to their first instruction on the typewriter was equivalent to writing nineteen pages on the machine. This coefficient as well as the predicted limit is based on the assumption that the unmeasured part of the learning before and after the observations followed the hyperbolic law. This assumption seems to be fairly safe since other learning curves, the actual observations for which start with practically zero attainment and continue almost to the practice limit, usually follow the hyperbolic form. See figure 11 which represents a substitution test learning curve carried almost to the practice limit, and the curve for subject No. 23 in figure 3 for typewriter learning which projects to the origin.

The *time-amount* curve is plotted as time, t, per unit amount
2 of work against number of formal practice acts, X. Its equation is

$$t = \frac{X+K}{L(X+P)} \qquad 49$$

with notation similar to that of equation 20. Learning data can be changed from the time-amount form into the speed-amount form and vice versa by noting the fact that speed, Y, is proportional to the reciprocal of the time, t, per unit amount of work.

The *time-time* curve is plotted as time, t, per unit amount of
3 work against total practice time, T. Its equation, 54, is derived from equation 20. This equation is too cumbersome for practical work and the speed-amount or time-amount curves should therefore be used unless one adopts a simple empirical equation for the time-time form.

The *speed-time* curve is plotted as speed, Y, against total prac-
11 tice time, T. Its equation, 55, is too unwieldy for practical work but it serves to demonstrate the following proposition regarding

positive acceleration. If we assume that the typical form of speed-amount curve is hyperbolic, then the learning curve in the speed-time form must necessarily have an initial positive acceleration which changes to a negative acceleration when the attainment has reached one-third of the limit of practice. The positive acceleration can not, of course, be obtained when the initial score is greater than one-third of the practice limit. It can only be observed when the initial score is less than one-third of the practice limit.

The influence of different values for the learning coefficients on the shape of the learning curve may be summarized in the following comparisons. Figure 7 shows two learning curves approaching two different limits at the same rate. Figure 8 shows two curves approaching the same limit at different rates. Figure 9 shows two curves approaching the same limit at the same rate but differing in the amount of previous practice. Curve A has a start of forty practice units over curve B. Figure 10 shows two curves, one approaching a high limit at a low rate, the other approaching a lower limit at a high rate. The important feature of this comparison is that one who learns rapidly but with a low limit will do better in the first stages of the learning than one who learns slowly with a high limit. The comparison shifts later in favor of the learner with the high limit. This is a condition which experimenters on learning should be on the look-out for in order to guard against the erroneous comparison of two subjects from insufficient practice data.

2) Outline for Calculating the Learning Coefficients

We shall describe two methods of calculating the coefficients. These are 1) the method of all points, and 2) the method of three points.

1) *Method of all points:*

1) Arrange the data in two columns as follows: X, the total number of formal practice acts since the beginning of practice, or a multiple of this number, and Y, the number of successful acts in unit time, or a multiple of this number. The multiple

used for the Y-column need not of course be the same as that for the X-column.

2) Draw a chart analogous to figure 5. Leave room for a negative x-intercept. Always include the zero point of the y-scale on the chart.

3) Select a representative initial score. In figure 5 the actually observed initial score, 27, was used. Denote this by the symbol Y_1.

4) Compute the values of $X/(Y-Y_1)$ and $XY/(Y-Y_1)$ for each observation. Arrange these in two columns.

5) Draw a chart analogous to figure 6 with the coordinates determined in step 4. If the data so plotted fall nearly on a straight line the speed-amount curve is hyperbolic. If it does not, the use of the learning curve equation is not justified and other methods must be resorted to.

6) Fit a straight line through these points in figure 6 in such a manner that there are about as many points on one side of the line as there are points on the other side. This procedure is called "rectifying the equation." The line can be fitted more accurately by the method of least squares but since that is a rather laborious procedure it should be avoided unless the points are so badly scattered that they can not readily be fitted by inspection. Even then it is doubtful whether one is justified in applying the equation to learning data so erratic that a straight line can not be fitted by inspection.

7) Continue this line until it intersects the x-axis. The x-intercept gives the value of K/Y_1, and since the value of Y_1 is already known the value of K can be readily determined.

8) The slope of the line is numerically equal to the predicted limit, L.

9) The constant P may then be determined from the equation

$$P = \frac{K \cdot Y_1}{L}$$

10) The constant R is then determined by the equation

$$R = K - P$$

since K and P are known.

2) *Method of three equidistant points.*

The first two steps of this method are identical with the first two steps in the method of all points.

3) Draw a *smooth* curve through the observations. If the data show irregularities in the rate of learning draw the smooth curve so that it has approximately as many observations above the line as there are observations below the line. A ragged line through all the more or less erratic observations will not serve the purpose. If the smooth curve representative of the data is not of the hyperbolic form the method of this learning curve equation is not applicable.

4) Select the three following points:

$X_1; Y_1$

in which X_1 is zero, and Y_1 is the ordinate to the smooth curve at this value of X. If the learning data have no irregularities the value of Y_1 will be identical with the initial score.

$X_2; Y_2$

in which X_2 is one half of the total amount of formal practice and Y_2 is the representative ordinate to the curve for this value of X.

$X_3; Y_3$

in which X_3 is the total amount of formal practice and Y_3 is the ordinate to the smooth curve at this value of X. If the learning data show no irregularities, this will be identical with the final score.

5) Determine the numerical value of the constant K from the equation:

$$K = \frac{X_3(Y_2 - Y_3)}{Y_3 + Y_1 - 2Y_2}$$

6) Determine the numerical value of constant L by means of the following equation:

$$L = \frac{Y_3(X_3 + K) - Y_1 \cdot K}{X_3}$$

7) Determine the numerical value of the constant P by the following equation:

$$P = \frac{Y_1 \cdot K}{L}$$

8) Determine the numerical value of the constant R by the following equation:

$$R = K - P$$

After the constants of the learning curve equation have been numerically evaluated it is best to check the arithmetical work by computing the theoretical value of the attainment for one or two points according to the following formula. These theoretical values of attainment should not differ much from the actually observed values unless the learning has been very erratic.

$$Y = \frac{L(X+P)}{(X+P)+R}$$

A gross measure of the variability of the learning may be determined from the equation

$$V = \frac{D}{y_a}$$

in which D is the average deviation from the theoretical curve for all the observations, and y_a is the average attainment as determined from all observations.

3) Typewriter Learning

The following relations were found to be significant with regard to typewriter learning.

The correlation between the predicted practice limit and the average writing speed for all tests which covered about seven months is +0.68. The correlation between practice limit and rate of learning is +0.75. This indicates that those who approach a high practice limit usually do so at a lower rate than those who approach a low limit since the coefficient, R, for the rate of learning varies inversely with the rate of learning. There is a noticeable relation between accuracy and the predicted practice limit. Those who approach a low practice limit for writing speed are usually inaccurate, but those who approach a high practice limit are either accurate or inaccurate. On the other hand those who are inaccurate are either fast or slow writers. The number of subjects, 51, is not large enough to warrant the calculation of the eta-coefficient. The correlation between the predicted practice limit and speed as determined in the test at the 8th week is $+0.27$. There seems to be no relation between the predicted writing speed at the limit of practice and the number of errors made in unit time.

The number of errors made in unit writing time increases with practice. Similarly there is a positive relation between the number of errors in unit time and writing speed during practice. However, the number of errors per unit amount of work decreases with practice. See figures 16, 17, and 18. There is no discernible relation between the relative accuracy and the rate of learning.

Those who have a high practice limit for writing speed usually have larger relative deviations from their theoretical learning curves. The variability of the writing speed for any individual subject tends to decrease with practice, but if the student is a fast writer he tends to be more variable in writing speed, than if he is a slow writer, even when the variability is measured in relative terms. According to this standard of variability the writer of 60 words per minute is allowed a deviation from his representative learning curve twice that of a writer of 30 words per minute. But even according to this relative standard of variability the fast writers tend to be slightly more erratic in speed.

Considerable ambiguity in discussions about learning curves has been caused by the comparison of learning curves with different units for the coordinates. Thus we are entirely safe in saying that the speed-amount curve is never continuously linear. It would lead to infinite speed of performance which is of course absurd. But while that statement is obviously true it does not entitle us to jump to the denial of say linear error-time curves. It is quite possible for errors plotted against time to be linear. Therefore we should always specify the coordinates for the curves we are discussing.

While I have confined myself throughout to what I have called the typical hyperbolic form of the speed-amount curve it is quite essential to keep in mind that this form of curve is not universal and that consequently it is impossible to make sweeping generalizations except in so far as we explicitly limit ourselves to the relations which follow from the assumed hyperbolic form with which we started.

The preceding pages have been filled with so much algebraic manipulation that the reader who has long since dropped the algebraic thinking of his school days may find their very appearance formidable and distasteful. For the benefit of those who have acquired an aversion against symbolic notation I wish to call attention to the outline for calculating the coefficients and the section on learning curve forms in the summary. In those sections will be found all that is really essential in applying the method. If the use of empirical equations in the quantitative study of the multifarious aspects of memory is at all furthered by the present study I shall be content though the particular forms used here are superseded by others.

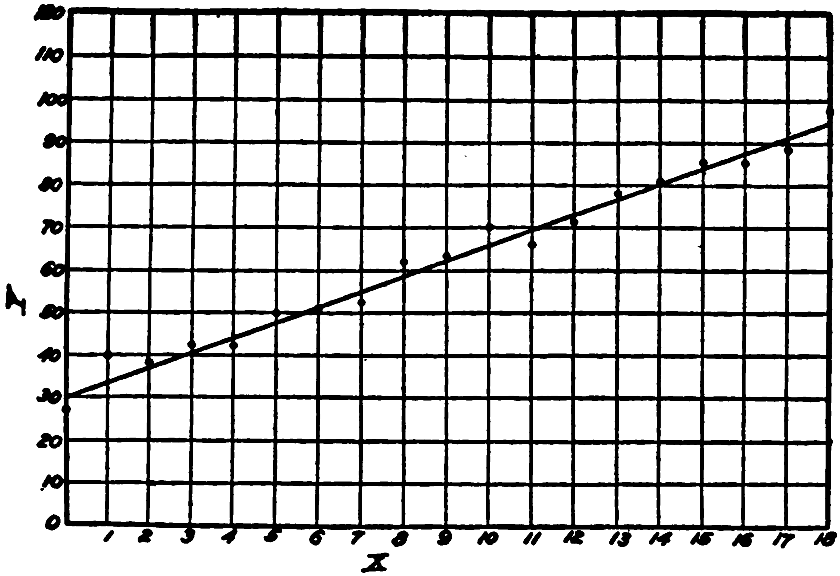
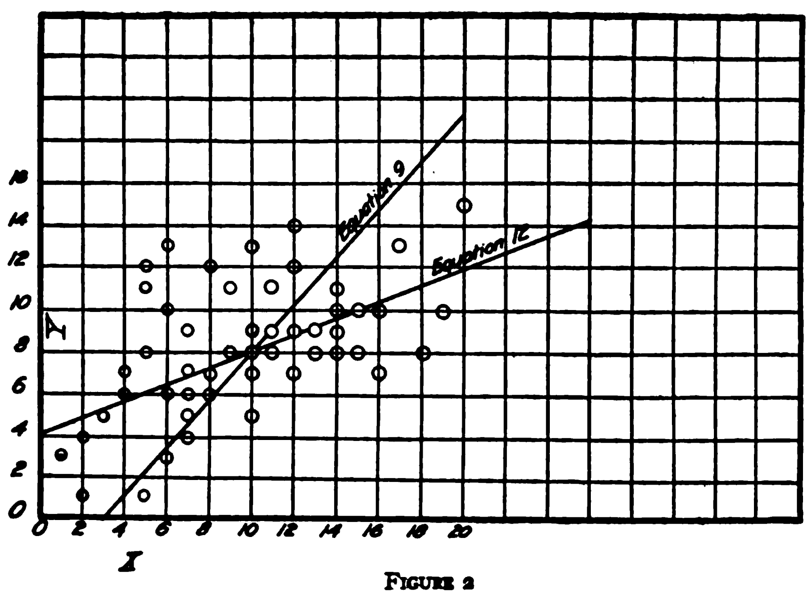


FIGURE 1



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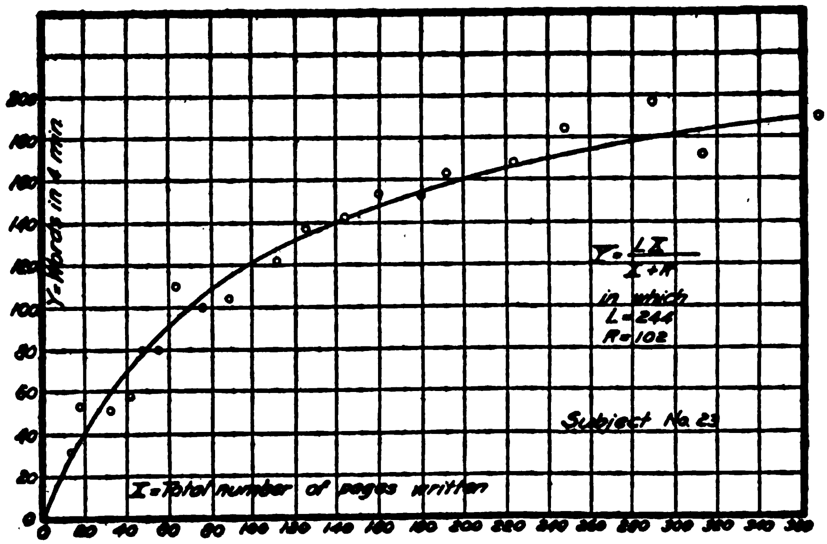

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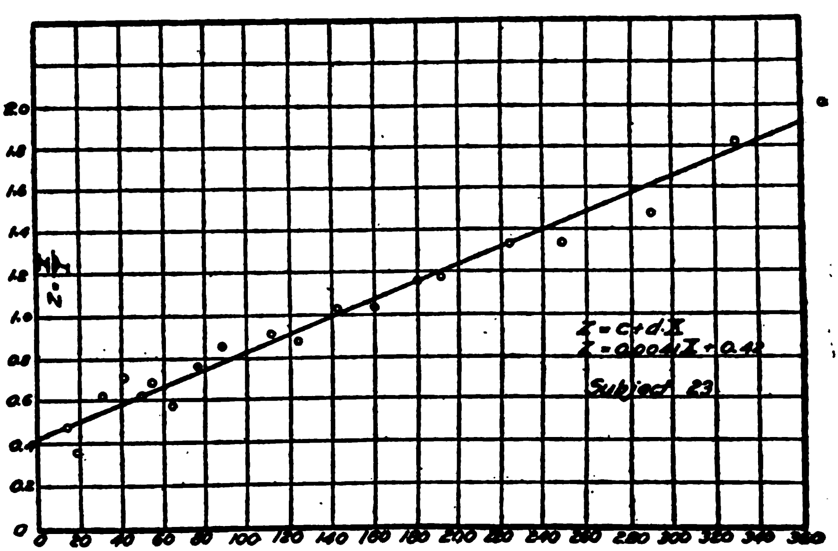

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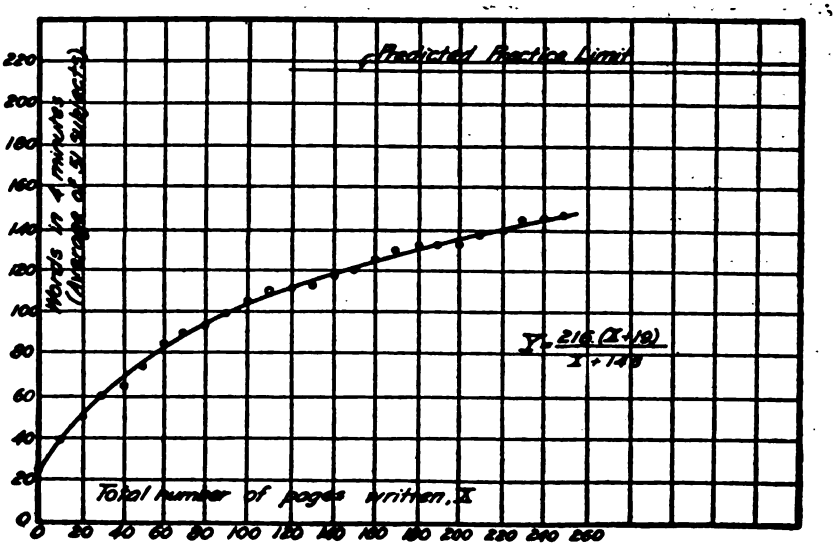

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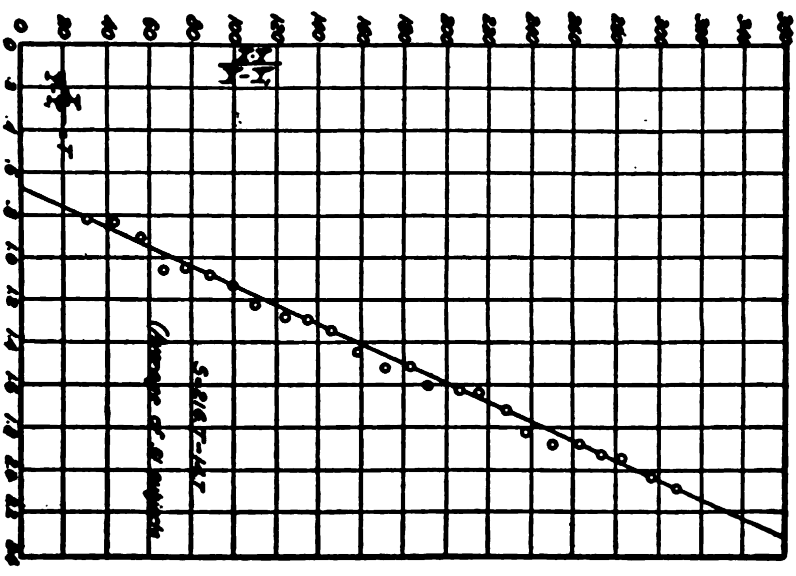

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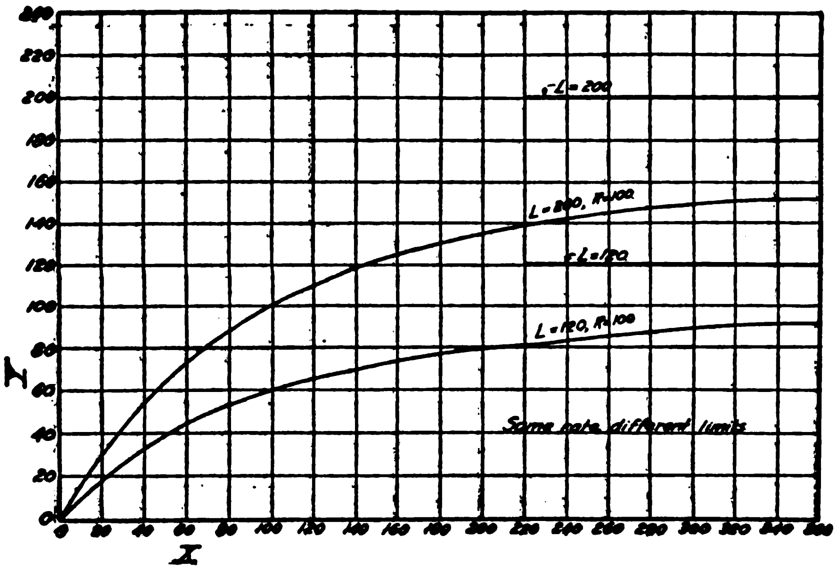

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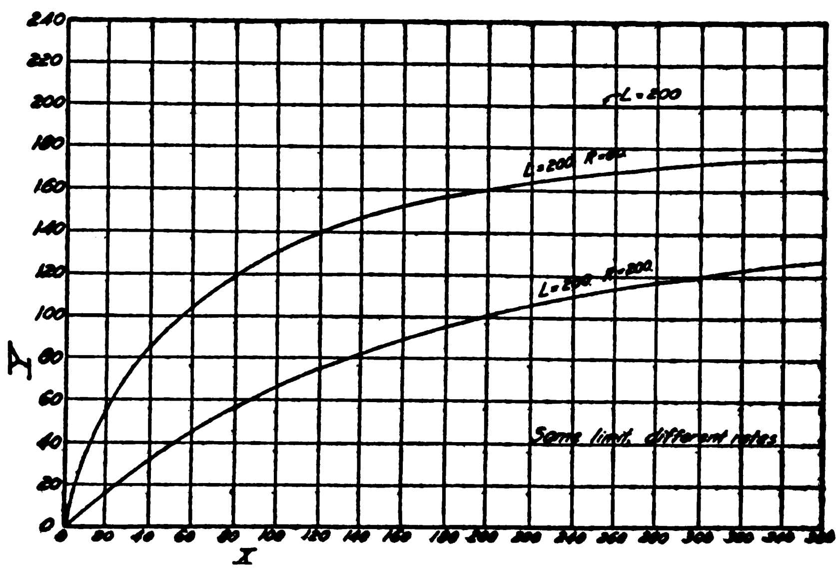

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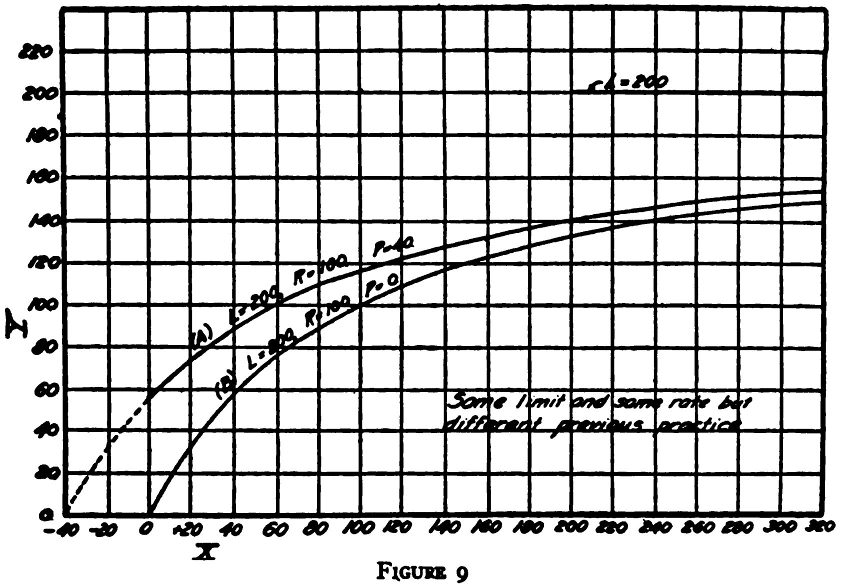

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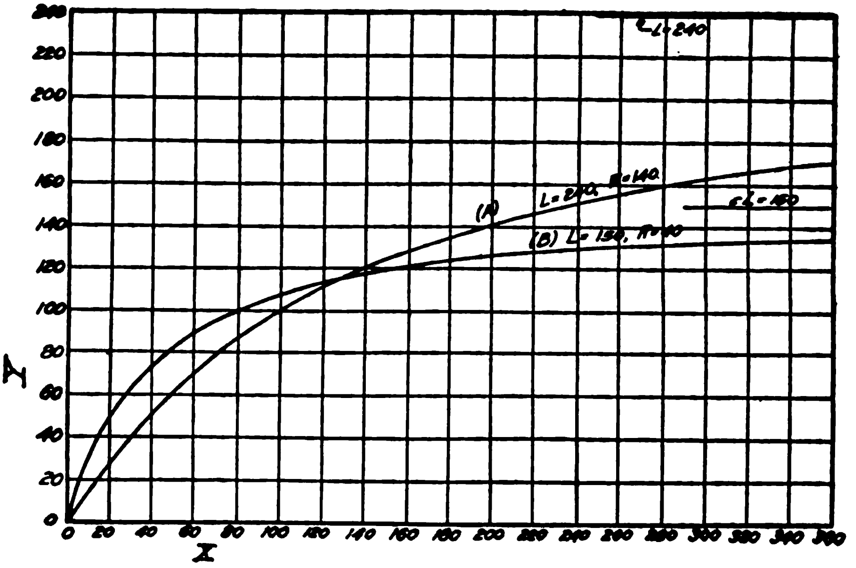

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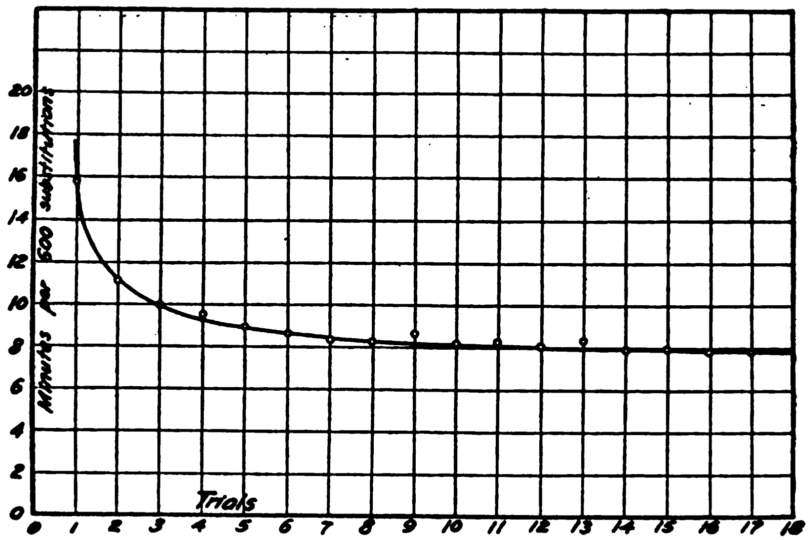

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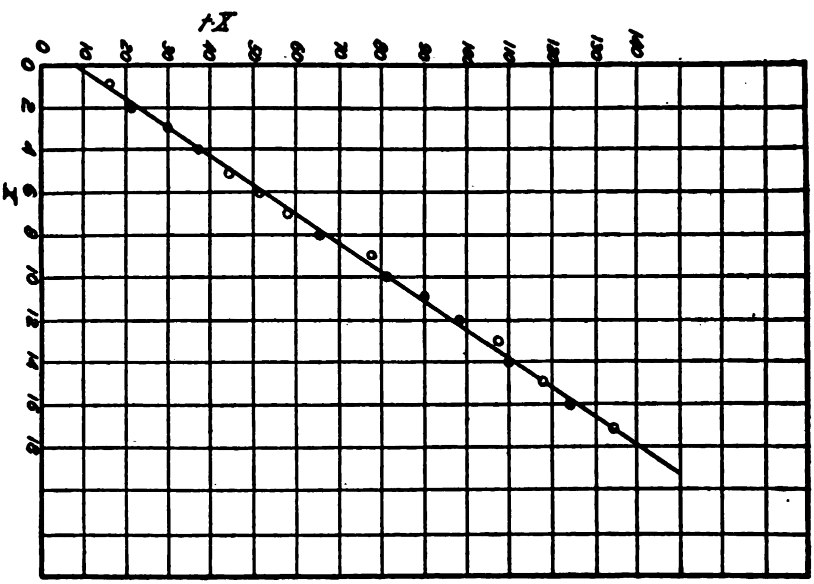

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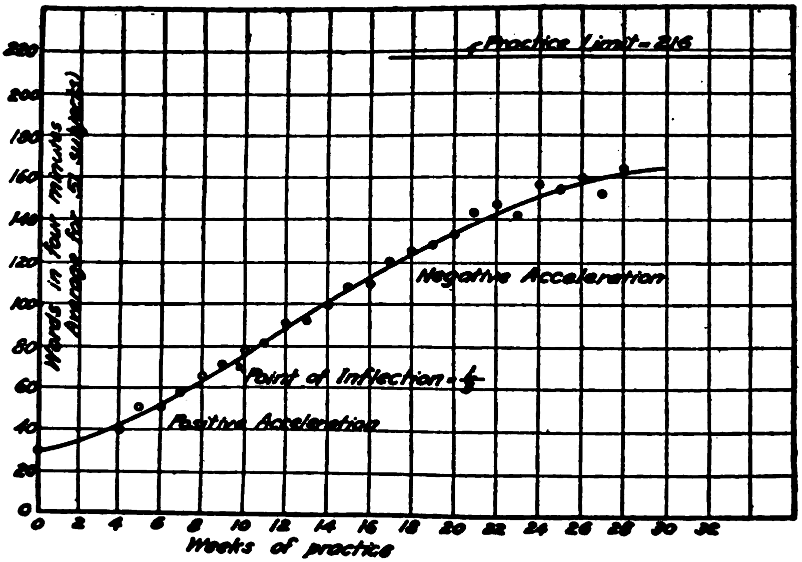

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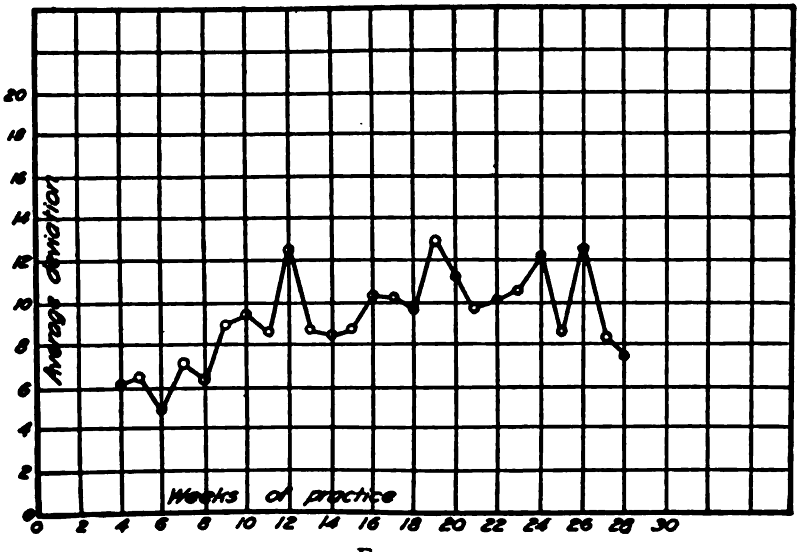

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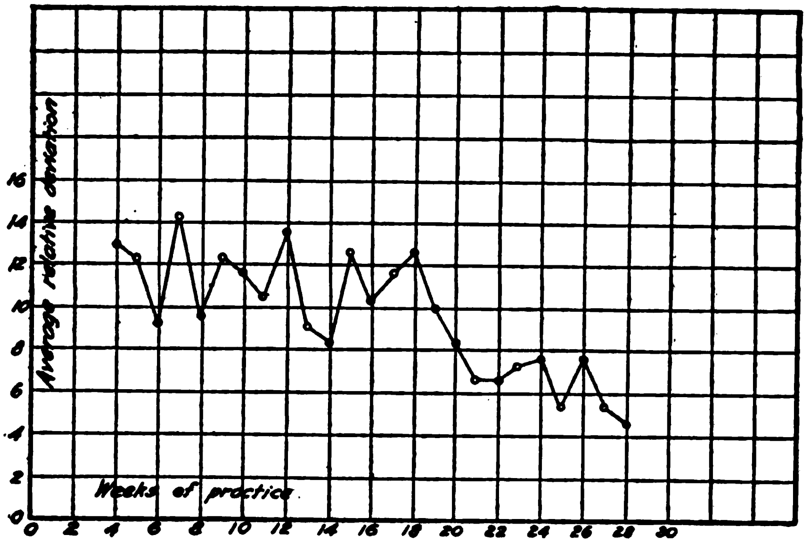

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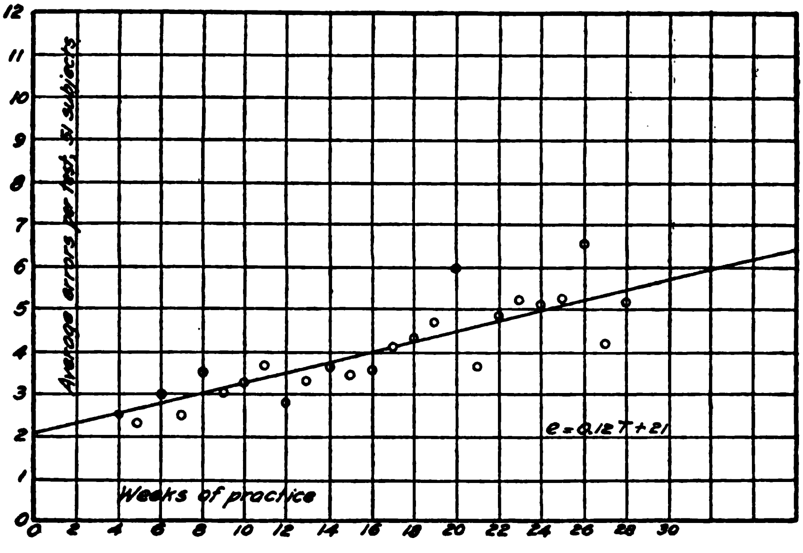

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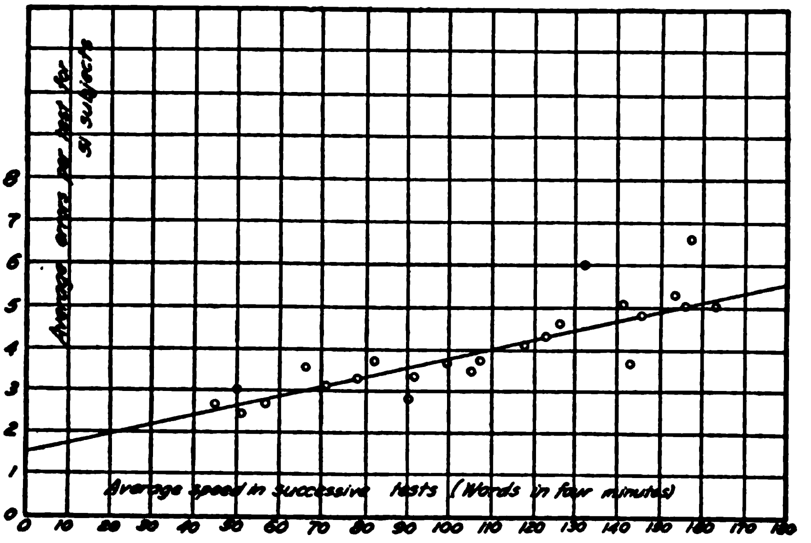

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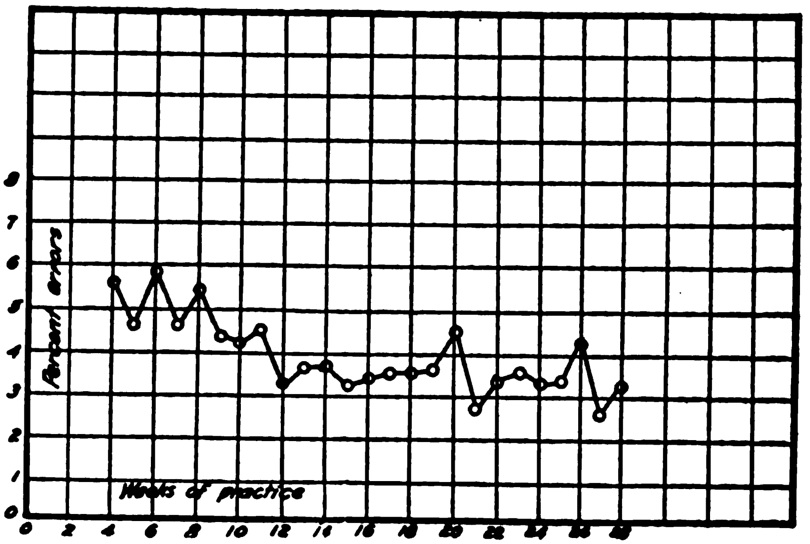

FIGURE 18

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STUDIES FROM THE PSYCHOLOGICAL LABRATORY OF THE UNIVERSITY OF CHICAGO

The Effect of Alcohol on the Intelligent Behavior of the White Rat and Its Progeny

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THE EFFECT OF ALCOHOL ON THE INTELLIGENT BEHAVIOR OF THE WHITE RAT

Introduction

These experiments, begun October, 1914 and ending June, 1917, were undertaken with a view to determining (1) the effect of alcohol on the intelligent* behavior of animals to which it was administered; (2) the effect if any on the non-alcoholic offspring of these animals. The first of these problems was suggested by the apparent lack of social efficiency present in a large proportion of humans addicted to the use of quantities of alcohol in its various forms; the second by the number of mental and nervous anomalies present in the offspring of drinkers. According to investigators of the etiology of mental deficiency, temporary or permanent alcoholism on the part of one or both parents is frequently the cause of mentally deficient children. Of the cases examined by Beach and Shuttleworth† 16.38 per cent had parental alcoholism as the sole cause; of those examined by Tredgold‡ 46.5 per cent had parental alcoholism as either the sole or the chief cause. In the case of the human the question always arises as to whether alcoholism is the cause of neurotic instability or the expression of it. Our chief aim was to determine whether alcoholism alone, working on a thoroughly healthy stock, could produce abnormalities of behavior in the first generation and mental and nervous anomalies in succeeding generations.

In order to obtain a stock of known antecedents whose environment could be controlled it was necessary to use animals as our subjects.

It is not here maintained that results obtained from animals will enable us to draw conclusions directly applicable to humans,

* By intelligence is meant the capacity to learn—to utilize past experience in the process of adaptation to a new situation.

† Mentally Deficient Children, p. 80.

‡ Mental Deficiency.

but it is maintained that such results will throw some light on the problem.

White rats were chosen because they thrive and breed under laboratory conditions, because they will readily take alcohol with their food and lastly because, if the problem be suited to their organization, they learn with great rapidity. The maze problem has been used extensively to study the learning process in rats and it has been found excellently adapted to the sense organ and muscle capacities of these animals. Maze learning, therefore, was the problem chosen as a test of intelligence.

A cut of the maze used appears on this page. Each section retraced in the true path and entrances into blind alleys constituted errors. The maze was considered learned when four out of five runs had been made without error. The number of trials taken to master the maze and the total time taken and the errors made before this occurred were the criteria used in judging relative intelligence. The only motive for running the maze was hunger. Punishment was at no time used. In no case are the records of animals frightened at any time during the training period included in the group records.

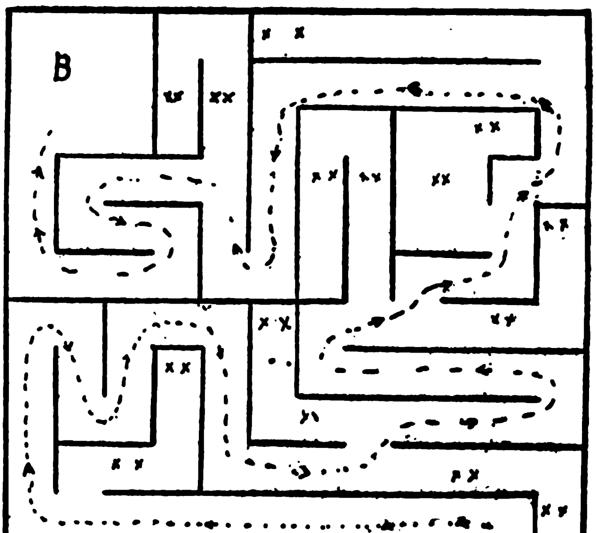

FIGURE I.—A—entrance to maze. B—food box. XX—blind alleys. Dotted line (......) shows true path.

Rats receiving 2 c.c. and 2 ¼ c.c. for 3 months were left in the maze until they found their way out at each trial. As this took more time than it was possible to give later sets a different procedure was employed with all other animals including three sets which received the same amount of alcohol for the same length of time as the three groups trained by the first procedure.

The second procedure differed from the first in that rats which failed to find their way out in 30 minutes in all trials after the first were removed from the maze at the end of this time. Fifteen hours were allowed for the first trial, and also for the twenty-fifth provided the animal had not found its way to the food box in the 23 thirty minute trials between the 2 fifteen hour trials. All animals failing to learn under this treatment were termed failures and their records not included in the group average. It must be understood that no animal was removed from the maze that was trying to find its way to the food box. It was removed only after it had remained inactive for ten minutes or more. Certain animals found their way to the food box, then failed. These were given 24 thirty-minute trials and one 15 hour trial. If they failed to run the maze during these 25 trials, they too were termed failures and their records not included in the group average. As a matter of convenience the term "failure" will be used throughout the rest of this paper in referring to animals exhibiting this type of behavior.

Failures usually moved past two or three turns in the true path, then went into a blind alley. After making aimless movements for two or three minutes, they went to sleep and remained so until the end of the trial. A few did not move more than a foot from the entrance of the maze. Very few alcoholics and no normals failed. The usual procedure with animals was to leave them in the maze until they found their way out of their own accord.

Alcohol was administered to our subjects by the feeding method. It was mixed with the bread and milk fed once daily to all animals. This procedure differed from that used by the majority of previous experimenters but it was chosen rather than any other, because (1) the exact amount of alcohol consumed by each group could be accurately measured; (2) it is possible to change the amount of alcohol administered without any radical change in the feeding procedure; (3) it makes the case of the rat more analogous to that of the human drinker.

Feeding methods heretofore used may be roughly grouped under four heads; stomach pump methods, in which the alcohol is introduced by means of the above-mentioned apparatus; fuming methods, in which eggs or mature animals are subjected to the action of alcohol fumes; absorption methods—in which eggs are placed in liquids which contain alcohol in solution; and feeding methods—in which the alcohol is given mixed with the food.

Hodge[4] used the stomach tube method with kittens, but found that respiratory tract diseases developed shortly after administration of alcohol was begun. This method is too difficult to use with small animals and is moreover as compared with feeding methods, unnatural and may induce emotional and other disturbances.

Variations of the fuming method have been used by a number of experimenters. Feré[2] experimented with the effect of fuming chick eggs on the percentage of chicks produced and the anatomical defects present. Chick eggs were subjected to the action of alcohol fumes, then incubated.

Stockard,[10] too, used this method with chick eggs to determine its effect on the structure of chicks hatched from eggs thus treated. It was used by Riddle and Basset[8] with pigeons to determine the effect of alcohol on the size of the yolk of the pigeon's egg; and by Pearl[7] with adult fowls to determine the effect of alcohol on the progeny of alcoholized fowl. Stockard[11] used the fuming method throughout his whole series of experiments concerning the effect of alcoholizing mammals on their progeny. In all of the above cited experiments the interest of the investigators was anatomical and in some instances physiological as well, but in no case purely psychological.

The method used in administering alcohol was so different from the feeding method as to warrant our expecting a different result from that obtained when alcohol was administered by the feeding method. Where eggs were fumed the embryos were in contact with alcohol fumes in the early part of their development. This condition is not analogous to the effect on the embryo of alcohol in the circulatory system of pregnant females, nor to its effect on the reproductive system of males. The fuming method used with animals themselves does, of course, permit of the introduction of alcohol into the system of pregnant females, or males and females about to be mated, but by this method alcohol is introduced through the respiratory tract. This leaves something to be desired if results obtained from this method are to apply to the human drinker whose alcohol comes into the system by way of the digestive tract. It was for this reason more than any other that the feeding method was used with our subjects.

Though the technique and the animals used in the Stockard experiments differed from ours the author wishes here to acknowledge her debt to these experiments for many valuable suggestions.

The method of absorption was used by Stockard[9] with fish eggs, and by Fletcher, Abbott and Arlitt[8] with chick eggs. In the former case the eggs were placed in a solution of alcohol and sea water; in the latter alcohol was injected into the air space of the eggs, the opening made for the injection was sealed and the eggs were incubated. The interest in the first experiment was anatomical, in the second psychological. Though the interest in the experiments of Fletcher, Abbott and Arlitt was like ours, psychological, the animals used and the technique differ so widely as to render a discussion in this connection of little value.

Nice, working with the effect of alcohol on the growth, reproduction and daily activity of white mice, used the feeding method that most nearly approximates that used in our experiments. Three c.c. of 35 per cent alcohol was mixed every other day with the crackers and milk offered to his subjects and the animals drank 35 per cent alcohol instead of water. Our subjects drank only pure water and the amount of alcohol, and the length of the feeding period before testing the effect of the drug on the animals was varied from group to group.

In the experiments previously cited none are comparable to ours in both method and interest; while some used the feeding method and some studied the effect of alcohol on behavior, none did both things. To the author's knowledge there is but one experiment comparable to ours, that of Hodge.[4] Hodge fed whiskey, wine, beer, and diluted alcohol to puppies and adult dogs, then tested the intelligence of these animals as measured by ability to retrieve balls and to obey commands. He records also the reproductive capacity of the first generation and the viability of the second. His interest was anatomical as well as psychological but no attempt was made to test the reproductive capacity of any generation after the first. Our experiments differ from his chiefly in that the intelligence of the first, second, third, and fourth generations was tested as well as their viability, whereas Hodge records only the viability of the second generation and does not attempt to experiment with any further generations. Also, no attempt was made to vary the size of the dose, or the duration of feeding.

In only two of the experiments cited was behavior the object of the investigation and in none was the procedure used in administering the drug exactly the same as that used by us; ours is, so far as we know, the only experiment in which the problem was to determine the effect of various amounts of alcohol administered for periods of different lengths on the intelligent behavior of the first, second, third, and fourth generation of white rats.

Our subjects were all bought from the same animal dealer. They were male and female rats approximately 93 days old when alcohol feeding was begun.

In order to eliminate group or strain differences our animals were chosen, from 25 to 50 at a time, at random from large groups bought for use in the laboratory. The remaining rats in each group, numbering from 15 to 60, were divided between two experimenters on other problems. The rats chosen by us were again divided at random into smaller groups of from 7 to 18 each. One of these groups was used as a normal control, the others were fed ¼ c.c. to 3 c.c. of 95 per cent grain alcohol per day per rat for from 16 days to 6 months before any tests of intelligence were made. This method of choosing groups eliminated the possibility that the differences in behavior manifest from group to group were due to strain differences. Our groups of normal controls chosen at random and all animals used by the two experimenters on other problems showed normal learning capacity. This could not have been the case in groups chosen at random, were any of the animals bought by us from defective strains.

All animals were kept 10 days before alcohol feeding was begun in order that any which had acquired diseases while in the care of the animal dealer might be eliminated. Only those in perfect health at the end of this time were used. One set was fed ¼ c.c., one ½ c.c., one 2 c.c., and one 3 c.c. of 90 per cent grain alcohol per day per rat for 16 days before tests of intelligence were made and throughout the testing period; four sets were fed ¼ c.c., ½ c.c., 2 c.c., and 3 c.c. respectively per rat per day for three months and two sets were fed ¼ c.c. and ½ c.c. for 6 months before tests of intelligence were made and during the entire testing period. Three normal control groups, raised under the same conditions, were run, one at the end of 16 days, one at the end of three months and one at the end of 6 months. These normal controls were the same age as the alcoholized animals. For the human of the same relative age and weight ¼ c.c. would be equivalent to 181.4 c.c., ½ c.c. to 362.8 c.c., 2 c.c. to 1451.2 c.c., and 2 ¼ c.c. (the dose actually taken by 3 c.c. rats) to 1632.6 c.c. of strong whiskey daily. The bread and milk to be given to each group was weighed and the alcohol to be administered added immediately before feeding. Twelve c.c. of bread and milk was allowed per animal except in the two cases where large doses were administered. Here 1 c.c. was deducted as the alcohol was considered to have the same effect as food. All food was given in china saucers and the animals fed on either a marble-topped, or a white oilcloth-covered table, to avoid absorption of the liquid content of the food. The maximum length of the feeding period was limited to 10 minutes in order to minimize, as far as possible, the evaporation of the alcohol.

Within the above stated limit, when rats left the food of their own accord, they were replaced in their cages. Food left by each set was weighed and a record made of the quantity. This amount was, except in the case of 3 c.c. animals, too minute to contain a measurable quantity of alcohol. Three c.c. animals actually averaged in amount consumed 2 ¼ c.c. of alcohol. These sets are therefore termed 2 ¼ c.c. rats. Animals were fed *after* each run in the maze. They were not under the immediate influence of alcohol while running.

I

Pathological Effects

Although our chief aim in this experiment was to determine the effect of alcohol on intelligent behavior, certain anatomical and physiological effects of the drug were so pronounced as to be worthy of note. Records of these were made primarily because of the light they might shed on the interpretation of our behavior data. They are given here, not only for the reason above cited, but because it was thought that they might be of value to readers whose interest was other than psychological.

Effect on Growth

An attempt was made to obtain records of the body weight and length of all animals used in the last year during which the experiment was in progress.

The apparatus used to obtain body lengths was a small box, one foot in length and two inches in width, with sides two inches in height. This box was open at one end and was without a cover. In the center of the bottom of the box was set a millimeter scale running lengthwise. The animal to be measured was placed in the apparatus with its nose touching the closed end and its body placed lightly against the scale. The body length from the tip of the nose to the root of the tail was then recorded. As the animals were very tame they could easily be held in the desired position. A difficulty presented itself almost immediately. The different states of muscular tension under which the animal was at the time it was measured caused a corresponding increase or decrease in the apparent length of the body. The records obtained proved so highly variable that they are not here included for discussion. The use of the caliper presented the same difficulty. This criterion, i.e. body length, was therefore not used in judging relative growth. Body weight was the only possible measure.

The animals were weighed on an ordinary apothecaries' scale. The weight was recorded in grams. Animals to be weighed were placed in a small, very light cage, the sides of which were made of wire and the bottom of wood. The cage was weighed before the rat was placed in it and its weight subtracted from the total weight of cage and animal. There were no difficulties to be surmounted in securing accurate weights, so it is on these that our conclusions concerning the effect of alcohol on growth are based.

As will be seen from the growth curves shown in Fig. II, rats receiving large doses, i.e. ¼ and 2 c.c. per rat per day, gained weight very slowly as compared with normals and in some cases actually lost weight though the animals were in the growing period. At the end of 9 weeks feeding, 2 ¼ c.c. rats weigh only 121.8 grams and 2 c.c. rats, though 10 grams heavier than normals when feeding was begun, only 130.1 grams, whereas normals at the end of the same period weigh 167 gms. At the end of 12 weeks the 2 ¼ c.c. group weighs only 116 gms. and the 2 c.c. group 125 gms., an average loss of 5 gms. per rat in the three weeks elapsing between the 9th and the 12th week. At this time normals weigh 188 gms., an average gain of 21 gms. per rat. Animals receiving ¼ c. c. and ½ c. c. per rat per day gain weight steadily, but show less gain at all stages than do normals.

Alcohol has its most pronounced effect on the growth rate of 2 c.c., 2 ¼ c.c. and ¼ c.c. rats at the end of the 12th week, that is to say, the most pronounced retardation occurs between the 9th and 12th week. It has an approximately equal effect on ½ c.c. rats from the beginning of the feeding period to the 9th week. In all cases alcohol causes a marked retardation in the rate of growth as judged by the disparity in body weight of alcoholics as compared with normals of the same age.

Effect of Parental Alcoholism on the Growth Rate of the 2nd, 3rd and 4th Generations

Parental alcoholism has a more marked effect on the rate of growth, than is present when the drug is administered to the animals themselves, as is obvious from analysis of the growth

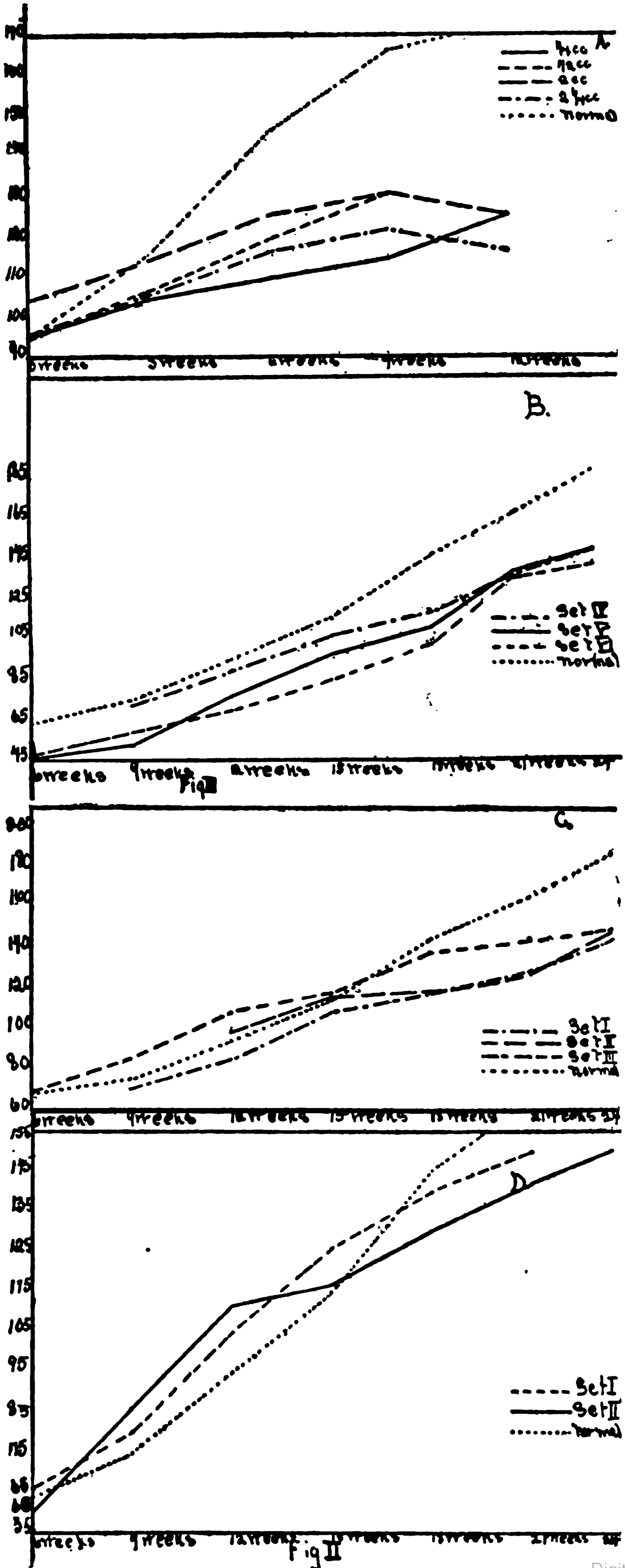

FIGURE II.—Effect of alcohol on the rate of growth. II A, first generation; II B, second generation. II C, third, and II D, fourth generation. [For amount of alcohol administered to each see text.]

curves shown in Fig. II. Retardation in the rate of growth is present to a marked degree in the 2nd generation and to a slightly less degree in the third and fourth. A comparison of the data contained in Figs. II B-IID (weights of 2nd, 3rd, and 4th generation rats) with the data contained in Fig. II A. brings out the following facts.

The defective body weight acquired by alcoholized rats is also inherited. The body weight of the second generation of alcoholic rats is below normal for the period of 6-24 weeks for which records were taken.

In the third and fourth generations the body weight approximates the normal until the 15th week and then drops below it. In all cases the body weight is below the normal from the 15th to the 24th week. Retardation of growth due to inherited defect is thus mainly evident at 15 weeks of age.

Comparing generations, it is evident from the graphs that the degree of retardation up to the 15th week becomes less and less with succeeding generations until the normal weight is attained. In other words the defect is eliminated by breeding for this period of age. This factor, elimination by breeding, will be discussed more fully in another section but it may be well here to state that we have anatomical evidence that this elimination occurred, if by 'elimination by breeding' one means that the germ cells themselves were in many cases so defective that young could not be produced from them; so that young of the second generation represent only those germ cells which were able to survive treatment with alcohol, or presumably the stronger cells. This elimination occurred for all generations succeeding the first. Only a few animals were sufficiently resistent to the drug to reproduce and of these only a few had offspring all of which survived.

For the period of 15-24 weeks the evidence is not conclusive, but as it is it indicates that the deficiency decreases from one generation to the next.

As to the relation of inherited defect to the amount and duration of the dosage the evidence is not absolutely conclusive, but in the majority of the cases the greater dosage is associated with the greater defect. In the two cases of hybrids (the offspring of matings between alcoholics and normal animals) both are below the normal curve of growth. As compared with abnormals, one is above, the other below the growth curve of animals both of whose parents were alcoholic.

Effect on Longevity

Data on the longevity of animals to whom alcohol was administered are given in Table I. Records were not kept for a period greater than 6 months, for at the end of the training period, the surviving rats were subjected to an autopsy.

Alcohol exerts a pronounced effect upon length of life. From 10 per cent to 82 per cent of the alcoholized rats died within six months, while no deaths occurred within this period in the control sets of normal animals. The number of deaths due to alcohol varies directly with the dosage. The percentages are 10, 24, 74, and 82 for the ¼ c.c., ½ c.c., 2 c.c., and 2 ¼ c.c. dosages respectively. It was found impossible to test the intelligence after 6 months feeding of the two larger dosages, as only one of the animals subjected to these two dosages survived for this period of time. This animal lived for 7 months after feeding began.

Alcohol exerts its effect very quickly. The number of deaths during the first week of feeding is approximately as great as that for any subsequent period. For the ½ c.c. and ¼ c.c. the number of deaths for the first and last halves are practically the same. The absolute number of deaths for the two larger doses is greater for the first half of the feeding period, but in proportion to the number in the group the mortality for the first half is slightly less than that for the second. However, the number of deaths is far from proportional to the length of the feeding period.

No records were kept of the longevity of the 2nd, 3rd, and 4th generations as all of these animals were subjected to an autopsy as soon as they had mastered the maze.

Effect on Fertility

Male and female rats of all alcoholic sets were mated with animals of the same set and with normals. The procedure fol-

TABLE I

Effect of Alcohol Feeding on Length of Life

Duration of Feeding Before Death	Normal Rats	Total No.	Deaths ¼ c.c.	Total No.	Deaths ½ c.c.	Total No.	Deaths 2 c.c.	Total No.	Deaths 2 ½ c.c.	Total No.
(Weeks)										
1	0		1		0		5		3	
2	0		1		1		8		13	
3	0		0		0		8		5	
4	0		0		2		10		5	
5	0		0		1		4		7	
6	0		0		0		0		9	
7	0		0		0		3		1	
8	0		0		0		0		5	
9	0		0		0		3		4	
10	0		0		0		4		2	
11	0		0		0		8		4	
12	0		0		0		2		4	
13	0		0		0		5		4	
14	0		0		0		1		4	
15	0		0		0		No sets of 2 c.c. and			
16	0		0		1		2 ¼ c.c. fed 6 mos.			
17 to 26	0		0		0					
22	0		2		4					
24	0		0		0					
Total	0		4	37	9	37	61	82	68	82
Percentage of Deaths		0%		10%		24%		74%		82%

lowed with the first three alcoholic sets was to mate at that point in the feeding period at which intelligence was to be tested. As no young resulted when mating was restricted to a specific time, males and females of alcoholic sets were left in the same cages throughout the feeding period except where matings with normals were desired. Abnormal females which were to be mated with normal males and normal females which were to be mated with abnormal males were kept in cages separate from males of their set for a period of three weeks before mating.

The 2 ¼ c.c. males and females were without exception sterile, both when mated with rats of the same set and when mated with normals. Six 2 ¼ c.c. males and a like number of females were left in the same cage for from one to three months (a pair to a cage) and during this time from one to three matings occurred. Two abnormal males mated with two normal females and two abnormal females mated with two normal males produced no young though left in the same cage for three months.

A like procedure was followed with 2 c.c. animals. Three 2 c.c. males were left in the same cage with three females of the same set for three months. During this time four matings occurred, but no young were produced. The same procedure was used with two abnormal males and two normal females and with two normal males and two abnormal females, but these also were without offspring. The only young born to 2 c.c. males were those produced after alcoholization had ceased for two months and the males were mated with normals.

Two 2 c.c. males mated with normal females after a feeding period of 5 months and a succeeding non-alcoholic period of 2 months produced litters of six each. One litter was eaten soon after birth. Two of the 6 young of the second litter were born dead. The four remaining young lived to be run in the maze. Too few males survived to render a repetition of this variation in feeding procedure advisable. Both females had normal litters before and after the mating with abnormals. The 2 c.c. males had no other offspring though mated twice during the alcoholic period and twice during the non-alcoholic.

As it was impossible to obtain young from 2 c.c. and 2 ¼ c.c. rats fed for even 10 days before mating, 4 normal females were mated with normal males. Ten days later 3 of these were fed 2 ¼ c.c. and 1, 2 c.c. per day per rat. Two of the first three had abortions one week later, one had a litter of 6 at full time. Of these 2 were born dead, 4 died when 13 days old. The 2 c.c. female had 5 young. One was abnormally small, one was still born, 2 died when two weeks old, and one when one month old.

As a variation of this experiment 2 normal males, never before alcoholic, were fed 2 c.c. and 2 were fed 2 ¼ c.c. and each mated with one normal female four hours later. Three litters resulted. One 2 ¼ male had no young though mating occurred. The litter of the second 2 ¼ c.c. male consisted of 5 young. One was still born, two died when 3 days old, and one died when three weeks old. The single surviving animal, a male, was run in the maze but completely failed to learn it. The 2 litters of 2 c.c. males consisted of four and six respectively when found by the experimenter approximately 18 hours later. Two of the animals in the litter of four died when 6 days old, one died when 2 weeks old, the last when 5 weeks old. The litter of 6 lived only 2 days.

Though no conclusions could be based on the results of these variations alone, they serve to throw more light on the effect of alcohol on fertility and on the viability of the young produced.

It was difficult to obtain young even from animals, receiving so small a dose as ½ c.c. per day per rat. Only two, and these still-born, resulted from attempts to inbreed the first 6 animals fed that amount for 6 months. Four matings between ½ c.c. males and females fed 6 months produced no young and no young were born after 9 months of alcoholization.

Of the second ½ c.c. set 3 females had litters by males of the same set. One had 3 young at the end of 5 months feeding. Two of this litter were born dead; one died 2 weeks later. One had 6 young after 5 ½ months feeding, and one after 6 months. Two in each litter were born dead and the 4 remaining in the second were eaten 2 weeks after birth. A fourth female had a litter of 6 young by a normal male after 6 months feeding. Two of these were still-born. The 4 remaining young did not live to be trained in the maze. One ½ c.c. female mated with a normal male after a feeding period of 4 months produced 7 young. One was still born, the remaining 6 lived to be trained in the maze.

The ¼ c.c. animals had more litters than rats receiving larger doses, but only a few of these survived. One female had 5 young after 6 ½ weeks feeding; one had 7 young after 3 months by males of the same set. In each case all died the following day. One female had 7 young by a male of the same set after 6 months feeding. Four died immediately after birth; three lived to maturity. This same rat mated to a normal male 7 weeks later had 6 young, all of which died the following day. The weather was unusually severe and the laboratory very cold. This is the only case of death of second generation which can be directly ascribed to external conditions. One set of 4 young, born of parents fed ¼ c.c. for 39 days, one set of 9 born of 2 normal females and a ¼ c.c. 6 months male, and one set of 5 young born of ¼ c.c. four months parents, together with the first set discussed, numbering 3, born of ¼ c.c. 6 months parents, were the only surviving offspring born of the matings between ¼ c.c. rats and those of the same set and 4 cross matings between these animals and normals.

This tendency to sterility in alcoholized animals stands out all the more clearly when contrasted with the fertility of normals of the same age. In the period covered by the above report 2 sets of normal animals of 6 each had 38 healthy young born of 5 matings, exclusive of those born of cross matings with alcoholics. Only three of these young died. In addition to the 38 healthy young, two normal females had litters, one of four, the other of 5 young, which were eaten immediately after birth. Fifteen of the surviving young were trained in the maze at the same time as the abnormal second generation animals; the remaining 20 were given to two experimenters on other problems.

Set I of the second generation (male parent 2 c.c. 5 months, no alcohol 2 months; female parent normal) was sterile though mated twice. Set II of ½ c.c. 5 ½ months parents produced 13 young when inbred, nine from the first mating and 4 from the second. No young resulted from crossing the males of this set with normal females, as the males died soon after the first mating. Eighteen young were born of a mating between a normal male and the two females.

Sets III and IV whose parents received ¼ c.c. for 39 days and 4 months had 12 and 13 young, respectively, when inbred. Eleven of each have been trained in the maze. One male of Set III and one of Set IV had litters by normal females of 4 and 6 each respectively. One of the former litter died soon after birth, all of the latter survived. Set V was also sterile though twice crossed with normal males and twice with normal females. As Sets VI and VII were born towards the close of the experiment, no attempts were made to test them for fertility.

Set II of the third generation, parents Set III of the 2nd generation, produced one litter of 7 apparently normal young. No further tests of fertility were made as these animals were killed for pathological examination.

There is apparently a selective process at work in the case of Set III third generation, the offspring of Set II second generation. Only one male and one female had young, though attempts were made to inbreed and to cross other males and females with normals. Three males and 3 females of Set I were left in the same cage together for 6 months. Two males were left in the same cage with normal females and two females with normal males for three months. The author observed no mating in any of these cases and no young were produced though the animals were left together at the mating season. With the exception of this set of the third generation and Set I of the second generation no tendency to sterility was present in the surviving offspring of alcoholized animals. The surviving 2nd generation animals were, as will be seen when the results of the pathological material which follow have been studied, probably a highly selected group.

To sum up the results of alcoholism on reproductive capacity:

(1) Alcohol produced complete or partial sterility in those rats to whom it was administered.

(2) The degree of sterility is proportional to the size of the dose. Our results allow no confident assertion as to the relation of the degree of fertility to the duration of feeding.

(3) The sterility effected characterizes both males and females, since both are sterile when mated with normal animals.

(4) This sterility is not due to lack of sexual desire as a normal number of matings occurred.

(5) This sterility is not a seasonal affair as normals of the same age bred successfully at the same time.

(6) Alcohol produces abortions in pregnant females.

(7) The degree of sterility is partly overcome by stopping the feeding.

(8) When conception does occur, alcohol increases the number of still births and increases infant mortality.

(9) This sterility and lack of viability of the offspring is inherited to some degree by the second and third generation. The degree of inherited defect is proportional to the degree of acquired sterility.

(10) With ½ c.c. and 2 c.c. animals the inherited defect is greater than the acquired sterility and the degree of sterility keeps increasing with successive generations. There is no recovery from the induced sterility, i.e. it does not breed out.

(11) The defects due to alcohol are eliminated by the non-production or elimination of offspring, that is, what occurs is the elimination of the tainted stock rather than an elimination of the taint while the stock remains.

The Effect of Alcohol on the Internal Organs

It was not until an examination of the internal organs of alcoholized rats was undertaken by Dr. Wells of the Department of Pathology of the University of Chicago, that the cause of the difference in fertility between alcoholized and normal animals was made clear. An examination was made of the testicles, stomach, heart, lungs, kidney and adrenals, and the liver of male animals fed from ¼ c.c. to 2 ¼ c.c. per day per rat, as well as their offspring. A comparison of the results obtained from these examinations with those obtained from the examinations of the same organs of non-alcoholic animals brought out the fact that only the generative tract of alcoholics showed definite changes, but here the effects were so marked and so nearly constant as to stand out conspicuously as resulting from alcoholization. The seminiferous tubules of alcoholic rats were on the average much smaller than those of normals. Not only was this the case, but equally definite changes were apparent within the tubules. These results have been published separately and we merely state the general results in this paper. To quote from the article, "The changes produced by alcohol take place in quite definite order. At first the spermatocytes seem to be normal in number and appearance, but there is soon noticed an increase in the number of spermatids in the tubules with a decrease in the number of spermatocytes. At the same time, or earlier, there is observed a greater diminution of complete spermatozoa with tails, than in the number of sperm heads.

"Apparently the first effect of the alcohol is to render the formation of spermatozoa incomplete so that heads are formed without normal tails. The next effect of the alcohol seems to be to prevent the transformation of the spermatids into spermatozoa, whereby the tubules become filled with accumulated spermatids with but few spermatozoa or none at all. In the most advanced stage the tubules contain but marginal cells with but few or no spermatocytes or spermatids." In this paper it is noted that the defects are the same as those present in the human alcoholic.

Before complete sterility occurs therefore, the animal is producing spermatozoa which show all degrees of abnormality. The connection between this condition of the male generative organ and total sterility or the production of defective offspring is obvious. Not all rats were affected alike which accounts for the absolute sterility of some animals as compared with the ability to reproduce present in others fed the same amount of alcohol for the same length of time.

The exact condition of the female generative organ, the ovary, of alcoholized animals is not known, though a brief examination of the same number of ovaries as testicles, i.e. 15, was made. Of the 15 ovaries, 2 were atrophic and several showed less ova than normal, but only an examination of serial sections which the authors were unable to undertake, would have revealed the exact changes present in alcoholized females as contrasted with normals. It is only fair to assume in view of the tendency to sterility present in females receiving large doses and the number of still births among the few litters produced by females fed small doses, that some changes other than those already noted were present.

II

The Effect of Alcohol on Habits Acquired Previous to its Use

Our first problem in studying the effect of alcohol on intelligence was to determine the effect of the drug on habits acquired previous to its use.

Three sets of animals were given two trials a day in the maze until all the animals in each set were making 8 out of 10 runs without error. The maximum number of trials necessary to attain this standard was found to be fifty. At the end of 50 trials, Set I was fed 2 c.c. per rat and Set. II 2 ¼ c.c. per rat every day and run in the maze daily as usual. Set III was used as a normal control. The alcohol was administered after the runs in the maze had been made.

The graphs in Fig. III show the results obtained from these groups.

Alcohol exerted no appreciable effect on the number of errors made. For this reason no graph or table of errors are given. At times the error records of alcoholic rats are above the normal about .3 of an error per trial, a result that may well be due to group differences. Alcohol thus decreases the accuracy or perfection of a well automatized act very slightly if at all. The time records for groups as a whole are given, Fig. IIIC, together with graphs showing the relative effect of alcohol on animals which have a high degree of resistance to the drug and on animals which succumb shortly after alcoholization begins (Fig. III A and B). It was thought best to plot the curves in terms of the average time for 10 trials rather than to show the irregularities which are present even in the time curves of normals when these curves represent variation from day to day.

As compared with normals, both groups of alcoholic rats show a marked decrease in speed after alcoholization begins, but the initial decrease does not occur for both groups at the same time,

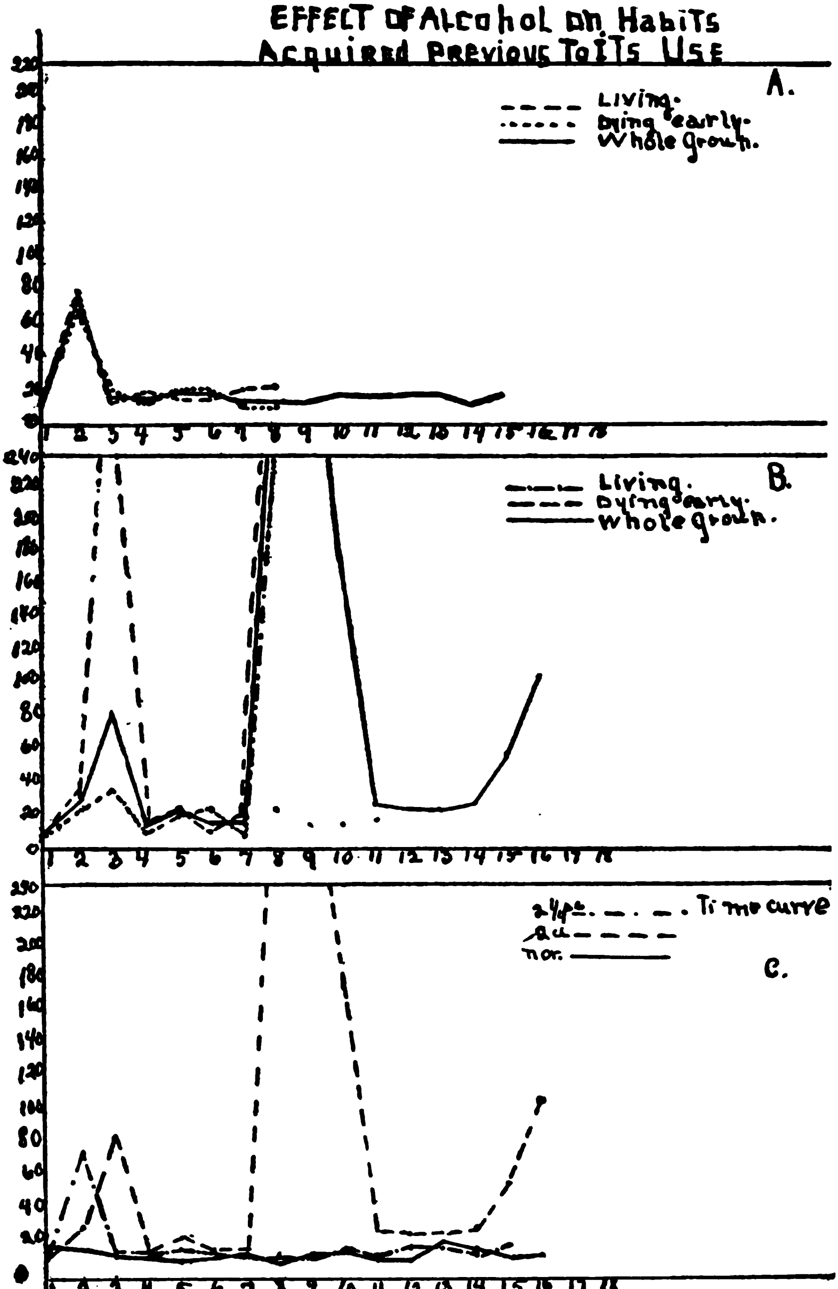

Fig III

FIGURE III.—A—The effect of 2¼ c.c. per day, per rat, on the functioning of a habit formed previous to its use, in rats surviving and in those dying shortly after alcohol administration signs. B—Same where the dose is 2 c.c. per day per rat. C—comparison of a normal curve with curves showing the effect of 2 ¼ c.c. and 2 c.c. per day per rat on the groups as a whole. Unit for time curve, one second.

nor is the behavior of the two sets subsequent to this the same. The 2 ¼ c.c. set showed the effect of alcohol at once. These rats failed frequently in the 10 trials after the first feeding: that is to say, they did not move more than one foot from the entrance to the maze for two 15 minute trials per day. This tendency to inhibit movement was the most noticeable effect of the alcohol. At the end of 20 trials some accommodation was present and from that time until the end of the feeding period these animals were no slower than a slow normal. The 2 c.c. rats did not show a marked breaking down in the maze habit until approximately two weeks after feeding had begun, at which time two rats died. They then showed accommodation to the effects of the drug for the next 40 trials, approximately three weeks. At the end of 6 weeks there is again accommodation which disappears for 20 trials before death occurs.

The experimenter was forced to be away from the laboratory 15 days. During this time the rats were in charge of an assistant.[1] Set I was run by this assistant from the 13th to the 15th trial[2] inclusive; Set II was run by her from the 5th to the 7th trial, and Set III from the 9th to the 11th trials inclusive. There was apparently no change in behavior due to the introduction of a new experimenter. This is probably due to the fact that the animals were too familiar with the maze situation to be easily disturbed by changes in external factors.

From the facts already cited we may safely conclude that alcohol does lessen the speed of performance of a habit acquired previous to its use. This lessened speed is not the result of working with a selected group. Except for the first rise in the time curve of 2 c.c. rats (Fig. III B), directly traceable to the slow running of two rats both of which died, there is no evidence to show that animals on which the drug has a slowing effect die before less affected animals. The curves for 2 ¼ c.c. rats of low and high resistance are practically synchronous (Fig. III A). Especially is this tendency of the two curves to overlap noticeable,

[1] Miss Moyer, a graduate student in the Department of Psychology, consented to run the animals in the maze during the experimenter's illness.

[2] By trial is meant, in this connection, point on the curve.

when it is remembered that they are not plotted in terms of large units, but in terms of seconds. Evidently the initial decrease in speed is due to the effect of the alcohol and the subsequent return to normal on the part of 2 ¼ c.c. rats and the partial return to normal on the part of 2 c. c. animals to accommodation, rather than to an elimination of animals in which the drug causes the most diminution in speed.

The results contained in this section show that alcohol does interfere with the functioning of habits acquired previous to its use in the direction of speed of performance. It does not interfere with accuracy to any appreciable extent.

There is a difference in the effect of the two doses. The animals showed a greater tendency to accommodate to 2 ¼ c. c. than to 2 c.c. doses. The previously cited differential effects are not due to the elimination of animals on which alcohol has the most pronounced effect in the direction of lessened speed, except in the case of the initial rise in the 2 c.c. curve (Fig. III C.).

Introduction of a new experimenter had no apparent effect on the behavior of alcoholized animals.

III

The Effect of Alcohol on the Intelligent Behavior of the First Generation

As compared with normals, alcoholics show decreased learning capacity according to all three criteria, viz., trials, total time, and total errors in 29 out of 30 cases (see Table II). The one exception refers to the errors for ¼ c.c. 10 days. With this single exception alcoholized animals took more trials and a longer time to master the maze and made more errors than normals of the same age raised under the same conditions.

Alcohol exerts its most pronounced effect on total time. At the end of 16 days feeding ¼ c.c. rats took 3018.3″, ½ c.c. rats took 9598.8″, 2 c.c. rats took 4316.6″, and 2 ¼ c.c. rats took 9767.5″ to master the maze as compared with the 1099.5″ taken by normals. At the end of three months feeding the disparity between the time required by normals and that required by alcoholics is even greater. Normals take 1131.6″, ¼ c.c., ½ c.c., 2 c.c., and 2 ¼ c.c. rats take 12016.2″, 2895.8″, 85406.2″, and 13022.2″ respectively. The total time taken by ¼ c.c. and ½ c.c. animals fed 6 months is 26481.6″ and 2397 respectively—as compared with the normal record of 1763″. This increase occurs not only for total time but for average time per trial as well, and the increase is not due to alcoholics taking a longer path. In 7 out of 10 cases the average error per trial made by alcoholics is less than that made by normals. In these cases the alcoholics actually took a shorter path. The increase in time over normals is due to the fact that alcoholics move very slowly and sometimes stop altogether. The most marked effect of the drug is therefore to lessen speed. The fact that alcoholics make fewer errors per trial than normals indicates that there is a diminution of exploratory tendencies.

The effect of the drug on trials and total errors is approximately equal. Both show, as has already been stated, a marked

TABLE II

Effect of Alcohol on the Intelligent Behavior of the First Generation

No. failing	No. learning	Amt. of alcohol	Total trials	M.V.	Total errors	M.V.	Total time	M.V.	Ave. time per trial	Ave. error per trial
					16 Day Group					
0	16	¼ c.c.	11.3	5.7	52.3	32.8	3018.3	3828.2	267.+"	4.6
0	17	½ c.c.	15.4	5.1	84.8	38.8	9598.8	10450.5	619.4"	5.5
4	9	2 c.c.	10.6	5.+	79.0	32.0	4316.6	5753.4	407.0"	7.4
2	6	2 ¼ c.c.	10.5	3.5	100.6	41.2	9767.5	9030.0	930.+"	9.5
0	5	Normal	6.7	1.3	55.5	17.0	1099.5	675.0	164.0"	8.2
					3 Mos. Group					
1	10	¼ c.c.	13.9	9.1	79.8	38.0	12016.2"	15748.9"	863.8"	5.7
0	5	½ c.c.	16.0	6.6	93.6	37.7	2895.8"	2816.0"	180.9"	5.8
2	6	2 c.c.	16.1	5.2	82.3	43.0	85406.2"	11552.5"	5304.1"	5.1
1	5	2 ¼ c.c.	20.8	5.3	120.2	24.7	13022.2"	11471.5"	626.0"	5.7
0	6	Normal	10.6	3.5	63.5	21.0	1131.6"	435.7"	106.7"	5.8
					6 Mos. Group					
1	5	¼ c.c.	20	11.0	133.2	61.4	26481.6"	894.2"	1324.0"	6.6
2	4	½ c.c.	14	7.0	70.5	22.0	2397.5"	854.2"	1498.0"	4.4
0	6	Normal	10.5	3.0	57.6	14.8	1763.3"	899.1"	167.+"	5.4
					3 Mos. Group					
					*Trained with First Procedure**					
0	6	½ c.c.	20.1	8.2	269.8	186.6	13822.6"	8320.1"	658.2"	13.4
0	5	2 c.c.	16.8	11.6	101.4	48.8	3260.0"	3412.8"	194.4"	6.0
0	6	3 c.c.	19.1	11.5	289.2	175.0	35298.0"	30694.7"	1844.4"	15.1

* As this procedure was used only with this group no discussion of results obtained therefrom is attempted.

increase over the normal indicating poor capacity to eliminate errors.

Lastly, alcohol increased group-variability. There was a marked difference in individual susceptibility to the drug even in sets fed the same amount of alcohol for the same length of time. The individual range of ability as expressed by the m.v. is, in 28 out of 30 cases, far greater than that in normal groups. The exceptions are for the times of the 6 months sets. The increase in variability would be greater and the exceptions eliminated were the records of the failures included. Failures are the extremes of group variability. The behavior of these animals has been described in a previous section. They could not learn the maze even when given two 15 hour and 24 thirty minute trials. Of the 13.2 c.c. rats fed 16 days, four, or 22 per cent, failed; of the eight 2 ¼ c.c. rats, 2 or 25 per cent, failed. Of the eight 2 c.c. rats fed 3 months before training, 2 or 25 per cent failed; of the six 2 ¼ c.c. rats, one or 16 per cent failed. At the end of 6 months feeding, 16.6 per cent of ¼ c.c. and 33 ⅓ per cent of the ½ c.c. rats failed. There had also been one failure in the group of ¼ c.c. animals fed 3 months. There is no correlation between the length of the feeding period and the number of failures per group. As to the relation existing between the number of failures and the size of the dose, the two larger doses produced the greater number of failures.

The greater range of variability in alcoholic groups may be due to the larger number of animals in these sets as compared with normals. That is, variability may be merely a product of relative size. Against this possibility we would urge two points: the records of sets as set forth in the tables are the result of combinations of smaller sets of from three to eight in number and where the sets contain as many as five animals and in one case where the set numbered only 3, the variability was still far larger than in normal sets; second, with the two exceptions of the times for 6 months sets, the records as contained in the table for sets numbering the same or even less than the normal sets show a wider group variability. We believe, therefore, that what we have is a characteristic effect of alcohol on group variability due to differences in individual susceptibility to the drug.

Two of the previously noted effects of alcohol, decreased speed and increases in trials and total errors, are roughly in proportion to the amount of the drug consumed.

It might have been expected that where the duration of feeding was the same, the effect of the drug would be in proportion to the amount administered. In the 16 day group this does occur. The ¼ c.c. rats are better than ½ c.c., ½ c.c. than 2 c.c., and 2 c.c. than 2 ¼ c.c. The time, trials, and errors of the 2 c.c. set would show marked increase were the records of failures included. Adding the records of the four failures to the group average of 2 c.c. animals and the two in the 2 ¼ c. c. group to that average, produces a record which shows a gradual decrease in learning capacity directly in proportion to the amount of alcohol per rat. (See Fig. IV.)

The number of failures in the 2 c.c. group as compared with the 2 ¼ c.c. rats can be better explained in terms of results obtained from the animals used in Section II. The drug, as has been previously stated, did not affect the behavior of 2 c.c. rats until two weeks after the first dose. At this time a number failed. The 16 day animals in Section II were probably feeling the worst effects of the drug at the beginning of the training

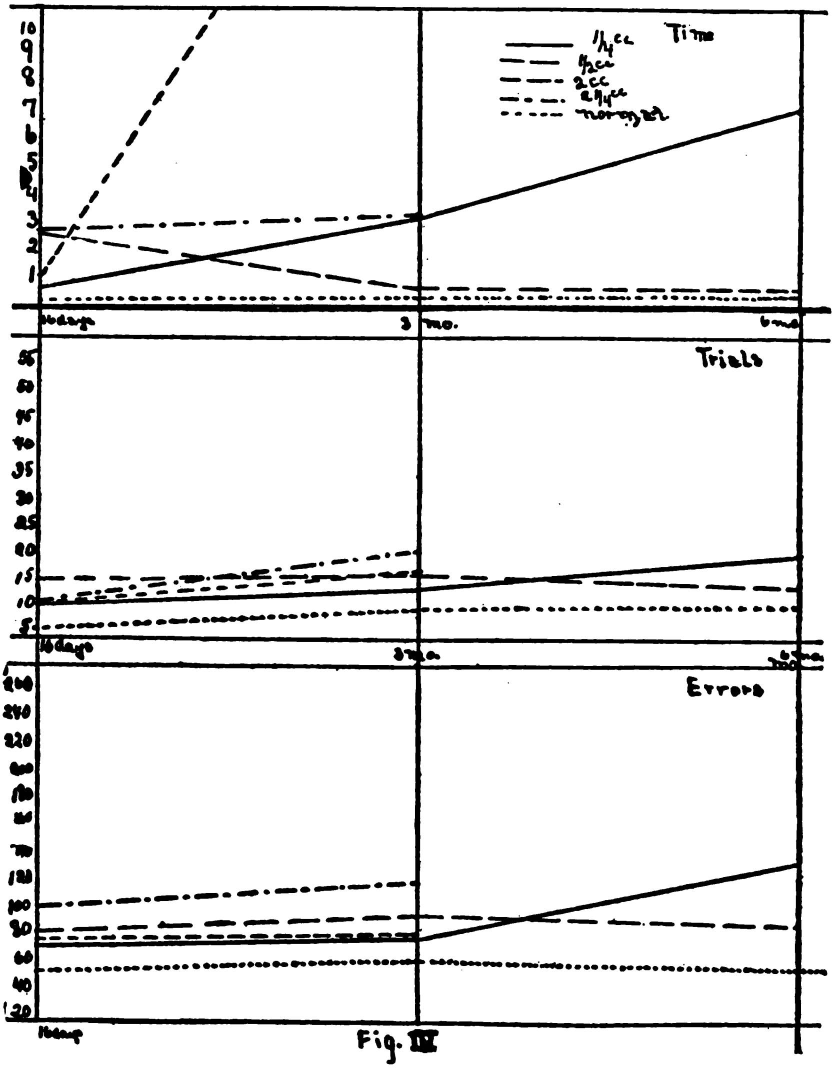

FIGURE IV.—The effect of duration of feeding with large, small, and medium doses of alcohol on time, trials and errors. Unit for time curve, one hour; for errors, ten; for trials, one.

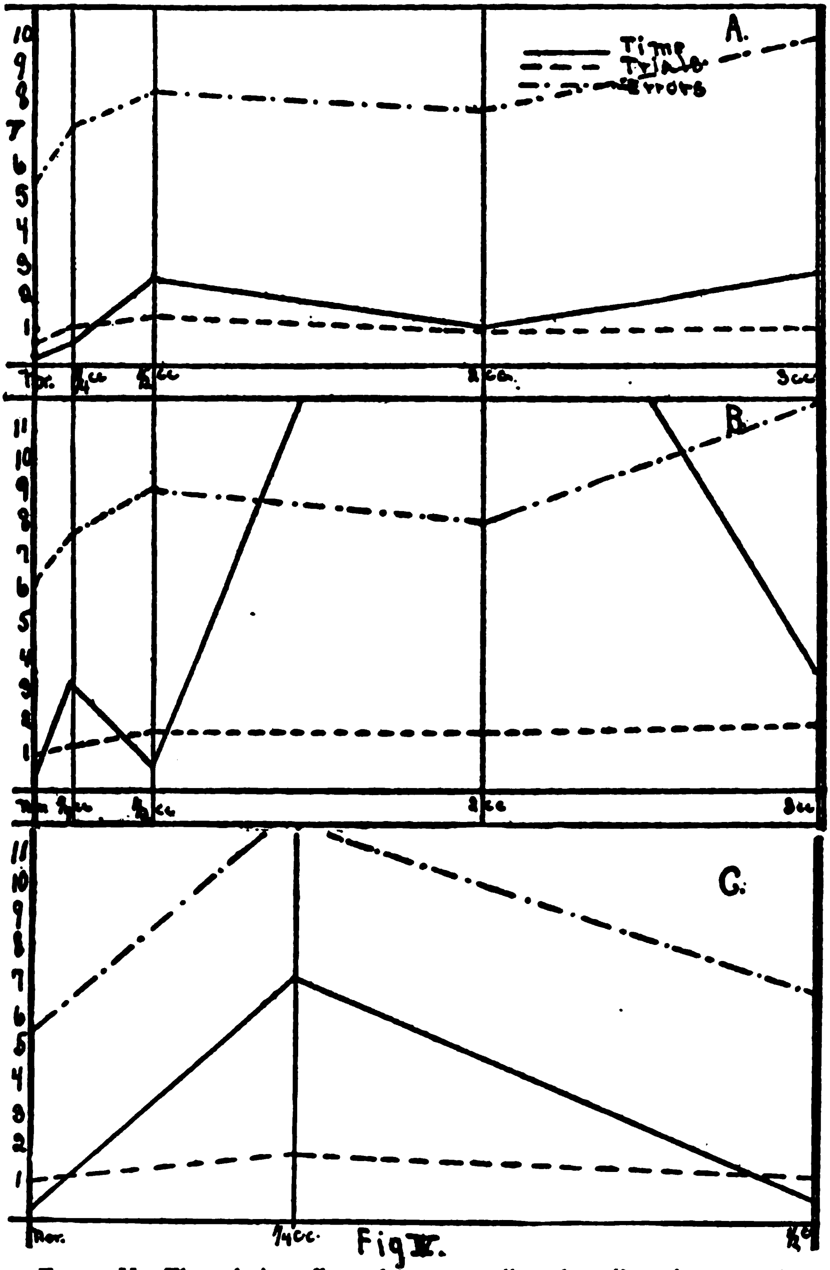

FIGURE V.—The relative effect of large, small, and medium doses of alcohol on time, trials, and errors, where the feeding period is of the same length. Unit for time curve, one hour; for errors, ten; for trials, one.

period and at that time acquired the habit of failing instead of that of learning the maze.

The 3 c.c. group in Section II showed the worst effects of alcohol the day after the first dose, then rapidly accommodated to it. If a like condition existed in the 2 c.c. and 3 c.c. animals used in Section III, the probability of failures in the case of the former would be much higher than in that of the latter. This seems a plausible explanation of the only peculiarity present in the records of the 16 day rats.

At the end of three months feeding many peculiarities appear in the records. Comparing the alcoholic sets, set for set with animals receiving the same amount for 16 days, all 3 months sets with one exception show an increase in all three measures over animals fed the same amount for 16 days. The one exception refers to the time for the ½ c.c. three months set (Fig. IV). Comparing alcoholic sets fed 3 months with each other (Fig. IV-V) and with normals, ½ c.c. rats take less time to master the maze than do ¼ c.c. animals, whereas 2 c.c. rats take longer to master the maze than do 2 ¼ c.c. animals. All are slower than normals. That is to say, if the animals were ranged in order as to speed of acquisition, ½ c.c. animals would come first after normals, ¼ c.c. second, 2¼ c.c. third, and 2 c.c. animals last, and adding the records of failures to the group average would only increase the disparity between ¼ c.c. and ½ c.c., and between 2 c.c. and 2 ¼ c.c. animals. The unusual speed of acquisition of ½ c.c. rats as a group was due to the records of two animals on whom alcohol seemed to have the effect of a stimulant to activity instead of its usual effect, i.e., a decrease in activity. The long time taken by 2 c.c. rats has as its explanation the strong tendency to fail manifest in all 2 c.c. sets. Of the 6 learning rats, 3 failed for from 2 to 15 trials, then learned the maze. Failing rats, as has been previously stated, average only 3 or 4 errors per 30′ trial. They do, however, have some opportunity to adapt to the maze situation even with this minimum of movement. The strangeness of the situation wears off and any fear which may have been present during the first two or three trials, tends to disappear. The records as to number of trials taken to learn the maze and as to errors made during and after failing trials would tend to show slight difference, if any, over those of rats at no time failing, thus making the record of the group as a whole poor as to time and relatively good as to trials and errors.

In the other two measures, trials and errors, with the records of failures included there is a gradual decrease in learning capacity in proportion to the amount of alcohol administered. In all three measures alcoholics are markedly inferior to normals. (See Fig. IV.)

There are only two alcoholic sets in the 6 months group, a ¼ c.c. set and a ½ c.c. set. As compared with normals these animals are much slower and make many more errors, but the disparity between ½ c.c. animals and normals is not so great after 6 months as it was after 3 months feeding. Only the ¼ c.c. set has shown progressive deterioration. In all three measures, time, trials, and errors, the set fed ½ c.c. 6 months is better than the set fed ½ c.c. 3 months. (Fig. V.) Either it is better to take a moderate quantity for a long period than a small quantity and even to take a moderate quantity for a long period than for a short, or some factor other than mere duration of feeding has entered by the end of the six month. This result could not have been due to the elimination of the less intelligent animals by the end of 6 months feeding, as only two animals have died by this time and these are too few to have any influence on the group record, even if it were certain that the rats which died were slow rats. Neither could it have been due to the fact that the records of failures are not included in the group average. Adding the records of failures does make the record of the ½ c.c., 6 months group slightly slower than the ½ c.c., 3 months set, but it does little to decrease the disparity between the former and the ¼ c.c., 6 months set, when the record of the single failure belonging to this set is also added to the group average. There are only two possible explanations of the fact that at the end of 6 months feeding ½ c.c. rats are better than ¼ c.c. animals; accommodation to medium doses and not to small doses, and the presence of some undetected disease in the ¼ c.c. set which did not attack the ½ c.c. animals. As to the first possibility, animals receiving large doses have, to some extent, accommodated to the effects of alcohol feeding but we have no evidence that animals receiving small and medium doses have shown accommodation up to this time. This, however, may be what has occurred in the six months group, as accommodation may come later with a medium than with a large dose. On the other hand the disease factor may have been the cause. Alcoholic animals were shown, when pathological examinations were made, to be very prone to bronchitis. As the severity of the cases was about the same in all alcoholic groups, this has not been cited as a possible cause for behavior differences, the severity of the disease being in no way correlated with the extent of the retardation of the learning process. We have no pathological data concerning this set as examinations were not begun until after the death of all of these rats. An unusually severe case of bronchitis or bronchial pneumonia may have caused, as has been stated, the slowing up of the ¼ c.c. set. We prefer, however, in the light of the facts, to explain the superiority of ¼ c.c. over ½ c.c. rats after 6 months feeding by the hypothesis that after prolonged feeding ¼ c.c. may be as deleterious as ½ c.c. with less possibility of its being accommodated to, or of its actually stimulating to swifter activity. The smaller dose did not stimulate to activity even after 3 months feeding, the larger acted as a stimulant to unusually swift activity in 2 of the 8 cases of animals fed ½ c.c. for 3 months and in 2 of the 4 cases of ½ c.c., 6 months rats.

Our facts, with the few exceptions discussed, are briefly, these:

Alcohol administered to white rats by the feeding method produces a decrease in learning capacity roughly in proportion to the size of the dose administered and the length of the feeding period.

Alcohol decreases learning capacity by (1) decreasing speed of running and (2) increasing the number of learning trials. It does not effect errors per trial.

There are various explanatory conceptions bearing on these results. In the first place, both increase in learning trials and decrease in speed of running may have been due to the fact that even at the end of 16 days our animals form part of selected groups. In the second place, increase in trials, i.e. poor capacity for elimination, may be due to (A) nervous changes which took the form of lessened retentivity of impressions in the nerve cells themselves, to stronger resistances at the synapses, or even to an overgrowth of sclerotic tissues,* or (B) to the effect of lessened speed. The maze habit is an association of sequent acts. A close temporal contiguity of these acts favors rapidity of association. It is easier to connect two acts occurring immediately together than when they are performed an hour apart. Therefore, speed of running tends to favor the association and slow speed to retard it. Lessened speed may be due to lack of hunger or to the neural changes previously referred to, which might make for insusceptibility to stimuli.

As to the influence of selection, in a previous section we noted that alcohol increases the mortality of animals. As a consequence our groups, especially for the larger doses and longer duration of feeding, are selected animals. For example, the set of 2 ¼ c.c. rats which learned the maze at the end of 3 months feeding, are the surviving members of a group of 43 rats. It is thus entirely possible that the above differential effects between the normal and the various groups of alcoholics are due to this process of selection. Such a result would obtain if it were the intelligent animals that first succumb to the effects of alcohol. As a matter of fact the results are not due to selection. (1) The mortality among ½ c.c. and ¼ c.c. groups is not sufficiently great to account for them. (2) For the 2 c.c. and the 2 ¼ c.c. dosages we determined the correlation between intelligent ability and rate of death for two groups composed of 14 and 16 rats respectively. They were allowed to learn the maze and after records of their relative ability were obtained, alcohol was administered by the usual procedure and the order of their death recorded. The two sets of data were correlated by the ranking method. The correlation data are recorded in Table III.

* No examinations have as yet been made of the nervous systems of alcoholized animals. No discussion of neural changes as a factor in producing lessened speed of acquisition is, therefore, attempted. It is hoped that the necessary data will be in hand shortly.

TABLE III

Correlation between Length of Life and Intelligence

No. of Rats	Dosage	Time	Trials	Errors
7	2 c.c.	+.543	+.426	+.324
7	2 c.c.	+.538	+.652	+.286
8	2 ¼ c.c.	+.191	+.858	+.620
8	2 ¼ c.c.	+.262	—553	+.143

The 2 c.c. animals were members of two groups of 7 each, the 2 ¼ c.c. animals of two groups of 8 each. The record of each group was correlated separately as in the case of both 2 ¼ c.c. and 2 c.c. animals, one group was given one trial a day until the maze was learned, the other two trials a day.

The records show that fairly large positive correlations obtain for the 2 c.c. group between resistance to alcohol and ability to learn the maze, measured in terms of time, trials, and errors. This means that the most intelligent rats were able to live the longest, while the least intelligent animals were the first to succumb. For the 2 ¼ c.c. animals the indices are on the whole lower and one of those for trials is negative. In one group of 2 ¼ c.c. rats the correlations for trials and errors are larger than in either of the 2 c.c. groups, but in the case of trials this is more than compensated for by the negative correlation in the other group, and in the case of errors by the low positive correlation in this second group. While one may doubt a significant positive correlation between resistance and ability to learn in the 2 ¼ c.c. group, yet it is certain that no such inverse correlation obtains as is demanded by the hypothesis that the above differential effects are due to a process of selection. Since it is the least intelligent animals that die first, it is evident that the members of our alcoholic groups that survived the preliminary feeding are the more intelligent animals. That is our alcoholic groups possess more intelligent capacity than the average run of normal animals. The process of selection thus minimizes the deleterious effect of the alcohol, rather than is responsible for it. Such results as we have, therefore, are due to the effect of alcohol on animals to which it was administered and not to the elimination of any particular type of intelligence.

There is only one other factor which remains to be discussed, some interference with hunger, which was the only motive for running the maze. Alcoholic rats received the same quantity of food as normal animals, and ate with the same speed, indicating that these animals were as hungry as non-alcoholic rats. They did not at any time show the behavior characteristic of animals which are not hungry; that is, they showed no tendency to leave the food dish for at least five minutes after they were placed on the feeding table.

To sum up the material contained in this section: Alcohol has a pronounced effect on the learning process, namely, a decrease in speed and an increase in trials and errors. This effect is not due to the elimination of the more intelligent rats as those eliminated are actually the less intelligent individuals. Neither is this effect due to any interference with the hunger motive. Our only explanation of the differential effects previously discussed is some characteristic change of which we have as yet no anatomical evidence in the structure or function of the nervous system.

IV

The Effect of Parental Alcoholism on the Intelligent Behavior of the Non-Alcoholic Offspring

The second generation of young from alcoholic parents were raised under the same conditions as were the offspring of normal rats. No young of the second, third and fourth generations received alcohol. In both cases every precaution was taken to prevent infection and all animals which showed signs of illness were at once removed from the rest of the group and were not used in experiments. A single exception to this was made in the case of a very few animals which developed bronchitis during the last part of the period in which they were trained in the maze. These were allowed to continue until the maze was mastered as this disease was found not to interfere with the speed of learning where the habit was practically formed. These animals were kept in separate cages, however, in order that the other animals might not be infected.

As a matter of convenience all second and third generation young from alcoholic parents will hereafter be termed "non-alcoholic" young, and all young from normal stock, "normals."

The effect of parental alcoholism on the intelligent behavior of the surviving offspring is shown in Table III. At the age of 66 days all second generation animals were trained in the maze used in Section I. They were given one trial per day until four out of five consecutive runs had been made without error. Time, trials, and errors before the maze was mastered were the criteria used in judging relative intelligence.

The records of the second generation bring out clearly the fact that parental alcoholism does affect the intelligent behavior of non-alcoholic offspring, even when it is confined to the male parent alone. In Sets I, II, V and VI the effect of parental alcoholism is uniformly bad. Set I, the offspring of a 2 c.c. male under the influence of alcohol for 5 months and a subsequent

TABLE IV

The Effect of Parental Alcoholism on the Intelligent Behavior of the Second Generation

Set	Male parent	Female parent	No. failing	No. learning	Total trials	M.V.	Total errors	M.V.	Total time	M.V.	Ave. time per trial	Ave. error per trial
I.	2 c.c. 7 mos.	Normal	0	4	35.2	10.8	240.0	62.4	37281.5"	51751.8"	1059.0"	6.8
II.	½ c.c.	5 ½ mos.	0	4	23.5	9.5	162.2	69.3	8754.7"	6621.3"	372.5"	6.8
III.	¼ c.c.	39 days	0	4	8.0	1.0	70.5	13.0	1417.5"	574.0"	177.1"	8.8
IV.	¼ c.c.	4 mos.	0	5	9.5	3.3	28.2	8.5	300.0"	98.4"	31.7"	3.+
V.	¼ c.c.	6 mos.	0	3	28.0	1.+	153.6	32.8	24001.6"	11251.1"	857.2"	5.4
VI.	¼ c.c. 6 mos.	2 normals	0	9	16.7	4.1	119.1	35.0	9767.6"	1652.0"	584.8"	7.1
VII.	⅓ c.c. 4 mos.	Normal	0	6	6.6	1.6	28.5	7.0	694.0"	226.2"	105.1"	4.3
VIII.	Normal	Normal	0	15	8.0	2.5	44.5	17.1	1237.2"	1156.7"	154.6"	5.6

non-alcoholic period of 2 months and a normal female whose offspring, when mated with a normal male showed no abnormalities, take 27.2 more trials, and 35944.3″ more time, and make 195.5 more errors than young from the normal matings. Set II, the result of a mating between two ½ c.c. animals under the influence of alcohol for 5 months, take 15.5 more trials and 7517.5″ more time, and make 117.7 more errors than do normals. Set V, the offspring of ¼ c.c. 6 months rats, take 22764.4″ more time, 20 more trials and make 109.1 more errors than do normals.

On Set III parental alcoholism has little or no definite effect. The animals are slightly inferior to normals in time and number of errors but take the same number of trials to master the maze. Such differences as are present are such as may be accounted for on the basis of individual variations between groups.

An interesting feature of these results is the behavior of Set IV, the offspring of rats fed ¼ c.c. for 4 months before mating, and of Set VII, the offspring of a ½ c.c. 4 months male and a normal female. These animals take much less time to master the maze and make much fewer errors than do normals of the same generation. Set IV is slightly inferior to normals in the matter of trials, but Set VII is markedly superior in all three measures. This does not mean that all animals in Set IV were superior to normals. Some, as indicated by the mean variation, were unusually slow. The mean variation here is not large because the group is large since this group is actually smaller than the normal group and its mean variation is much larger. Neither is the superiority on the average of either group due to the fact that the groups are small, since compared with the third generation group of the same age, which is even smaller, they are still superior. We have, then, two phenomena, neither of which seems to be due to the relative size of the groups, which require an explanation; (1) the large mean variation, especially in time, in the records of Set IV and, (2) the fact that animals from alcoholic stock were actually better than normal animals raised under the same conditions. As to the former of these two facts there is little to state. This phenomenon is probably due to the difference in germ cells which enables some to resist entirely the poisonous effect of the alcohol and others to feel its effect only slightly. In the former case young produced from these cells would not be below normal, in the latter the young produced would show certain characteristic behavior changes. Hence there should be present in the surviving young all degrees of defect. This would explain the large mean variation in the time taken by Set IV to master the maze.

The increased speed of learning indicated by the group averages of Sets IV and VII may have been due (1) to a heightened nervous excitability analogous to that found by Lashley[5] in strychinized animals; (2) to the elimination of less strong germ cells and a consequent bettering of the stock, as Dr. Pearl suggests was the case with alcoholized fowl; (3) to some beneficial effect of the alcohol on the parent animals.

The third of these possibilities can be dismissed without a lengthy discussion. The results previously cited of examinations of the generative organs of alcoholized animals, together with the fact that not even those receiving the minimum dose lived longer than one year, would banish at once any hypothesis which took into account the possible beneficial effects of alcohol; while at the same time they bring much to the support of the first hypothesis, namely, that alcoholization may have eliminated the less strong germ cells. In no case of a ¼ c.c. or ½ c.c. per day animal were all spermatozoa normal, and in many cases the seminiferous tubules were packed with spermatids which degenerated without attaining maturity. Obviously numerous germ cells were eliminated by reason of alcoholism. This alone would be sufficient to explain our results, but it is perfectly possible that the nervous excitability which Lashley found in strychinized animals was also a factor with offspring of alcoholics since all these animals which learned the maze in less time trials than the average normal were unusually active and moved with great rapidity.

An examination of the heart, lungs, kidney and adrenals, stomach and liver showed no disease present which would in any way account for behavior differences—these must, therefore, be due to parental alcoholism alone.

To summarize the material contained in this section:

Parental alcoholism may have as its effect an increase in average time and number of trials necessary to master the maze. This occurred in Sets I, II, V, and VI.

Parental alcoholism may have a beneficial effect on speed of learning as measured by a decrease in time taken and errors made before the maze is mastered; this occurred in Sets IV and VII; or it may produce no definite effect whatsoever, as was the case with Set III.

All inferior groups were from parent stock fed alcohol for from 5 to 7 months; both superior groups and the single set on which parental alcoholism had no effect were from parent stock fed for four months or less.

Though there is not very much evidence as to the effect of large as compared with small dosages, such evidence as we have points to the conclusion that the effect of parental alcoholism is partially dependent on the size of the dose administered to parent animals.

Long feeding and medium or large doses act detrimentally; short feeding periods and small doses have either no effect or a beneficial one.

Examinations of the generative tracts of all animals except those in Set I and the males in Set II, all of which died before examinations could be made, demonstrated no definite changes. As might have been expected, a normal number of young were produced.

V

The Effect of Parental Alcoholism on the Intelligent Behavior of the Third and Fourth Generation

Third generation rats were trained in the same maze and with the same procedure as were the parent animals.

The behavior of the third generation resembles closely that of their parents (Table V). Here, as in the parent animals, relative intelligence is dependent upon the degree of alcoholism. Set II, 2nd generation, is less intelligent than Sets III and IV, 2nd, and has less intelligent offspring than either of these sets. In all three cases the offspring are less intelligent than the parent animals.

The offspring of Set II are much less intelligent than the parent animals. The fact that they take fewer trials and make fewer errors than do the parent animals, is more than compensated for by the number of failures. Here, as in the first generation, the total time, trials and errors would be greatly increased were the records of failures added to the group average. As compared with normal third generation animals, their set takes 9.4 more trials and 19014.2″ more time and makes 92.0 more errors even with the records of failures not included in the group average. In number of failures the third generation bears closer resemblance to the first than to the second generation. The second contains no failures whereas the first contains 2 and the third 4. This is the only respect in which the behavior of the third generation bears any resemblance to the behavior of the first generation of the same stock. In all respects the third generation of this stock is approximately as inferior to the second generation as the second was to the first. That is to say, when animals receiving ½ c.c. for five months are inbred the defectiveness present in the first generation is somewhat increased in the second and when this generation is, in turn, inbred the defectiveness is even more increased in the third. When the females of

Set II, 2nd, were crossed with a normal male, the third generation of offspring were, as contrasted with those resulting from inbreeding, slightly superior to normal third generation animals in trials and total time and only slightly inferior in trials. Crossing this alcoholic stock with normal, therefore, tends to eliminate the defectiveness.

The offspring of Set III, 2nd, a set which had showed slightly, if at all, the effect of parental alcoholism, are somewhat inferior to the normal third generation animals. A male of this set crossed with a normal female produced young superior to normal in all respects.

The offspring of Set IV, 2nd, a set which was itself superior to the normal second generation animals, are inferior to normal third generation animals and therefore inferior to the parent animals in total time taken to master the maze. In total errors this set is inferior to the parent animals but still superior to normal animals, in trials it is superior both to the parent animals and to normals. It is therefore slightly superior to the parent set in one measure but inferior in two. Inbreeding has produced an increased defectiveness. A male of this group mated with a normal female produced young even more inferior to the normal except in the matter of time. In this respect mating with a normal has been advantageous. As has frequently been stated increase in total time is, in all generations, the most characteristic effect of alcohol feeding. As animals of all generations ate as much as normals and remained as long by the food receptacle, there was no tendency to slow up because of lack of hunger.

To sum up: All alcoholic strains show an increased defect in the third generation when both parents are alcoholic. In two of the three cases the defect is less marked in the second generation than in the third.

The offsprings of matings between alcoholic and normals are superior to the alcoholic parent and in one of three cases slightly superior to normals as well.

In general, in the third generation as in the first and second generations, the most characteristic effect of the alcohol is to

TABLE V

The Effect of Alcoholising the First Generation on the Intelligent Behavior of the Third

First Generation: Parent of male parent	First Generation: Parent of female parent	No. of failures	No. learning	Total trials	M.V.	Total errors	M.V.	Total time	M.V.	Ave. time	Ave. errors
¼ c.c. 39 days	¼ c.c. 39 days	0	11	8.3	3.4	55.8	29.4	4516.8″	5232.4″	544.1″	6.7
¼ c.c. 4 mos.	¼ c.c. 4 mos.	0	11	6.0	2.9	34.7	14.1	5705.2″	7313.9″	911.5″	5.7
½ c.c. 5 mos.	½ c.c. 5 mos.	4	5	16.4	7.6	148.0	46.4	20357.4″	9481.6″	124.0″	9.0
¼ c.c. 39 days	Normal	0	3	4.6	1.1	34.6	5.8	397.3″	94.4″	86.7″	7.5
¼ c.c. 4 mos.	Normal	0	6	9.8	1.7	54.5	10.6	3838.0″	2972.0″	391.6″	5.5
Normal	½ c.c. 5 mos.	0	10	9.9	2.3	54.0	11.4	1152.8″	356.1″	116.0″	5.4
Normal		0	5	7.0	2.4	56.0	7.8	1343.2″	872.1″	191.8″	8.0

lessen the speed with which the maze is run. That is to say, alcoholic animals and their non-alcoholic offspring tend to stay much longer in the maze than do normal animals of the same age raised under the same conditions and run at the same time. A marked increase in the number of trials taken to master the maze and the number of errors made occurs only where the feeding period of the parent animals has been of long duration but in all sets of first, second, and third generation rats; with three exceptions, Sets IV and VII of the second generation and Set IV of the third generation; alcoholic animals take more time in the maze than do normal rats of the same generation. In every case the normal animals were raised under the same conditions and were of exactly the same age.

Had the deleterious effect of the alcohol stopped with the second generation, malnutrition or disease, without any definite germ cell modification might have been assigned as the cause. This was not the case. Set one of the second generation was sterile. Set II produced young much less intelligent than its parents when inbred and less intelligent than normals in one measure when crossed with normal males. Sets III and IV produced young whose behavior somewhat resembles their own even when mated with normal females.

Obviously the behavior differences present in the first and second generation are present also in the third.

The records of the fourth generation show but slight tendency to reproduce in the offspring the type of behavior which characterized the parent animal. Only two sets of the fourth generation animals have been obtained. Set I, fourth generation, is the offspring of the single fertile male of Set III, third generation, and a female of the same set. Set II is the offspring of a male and female of the third generation, Set II.

As there were no normal fourth generation offspring[1] the behavior of abnormal Sets I and II can only be compared with the behavior of the normal third generation set.

There is still a tendency to slower adaptations than those present in normal animals in Set I, whose parents were much slower than normals. Trials taken and the errors made are both slight-

TABLE VI.

The Effect of Alcoholising the First Generation on the Intelligent Behavior of the Fourth

Set	No. of failures	No. learning	Total trials	M.V.	Total errors	M.V.	Total time	M.V.	Ave. time	Ave. errors
I	0	7	9.0	4.6	62.8	21.4	1433"	898"	170.3"	8.9
II	0	6	8.5	2.2	44.8	12.5	1848"	931"	212.+	5.2
Normal	0	5	7.0	2.4	56.0	7.8	1343"	827.1"	191.8	8.0

[1] The normal third generation set died of a contagious disease which killed, also, several alcoholic sets.

ly greater than those of the second and third generation normals, but such a small variation from normal as we have in this set may be due to individual differences rather than to alcoholism. Set II, the offspring of Set II of the third generation, which showed itself superior to normals, is still superior in one measure, errors made, and but slightly inferior in number of trials and in length of time taken before the maze was learned. On the whole it seems better to assume that such defects as were present in the second and third generation have been bred out in the fourth.

That the defects present in the stock producing Set I, 4th, have been bred out through the non-fertility of a large proportion of the stock is obvious from a study of the proportion of fertility present in the third generation of these animals. As has been stated in Section I, the section containing pathological data, only one male and one female of this set produced young though attempts were made to breed the remaining animals both with rats of the same set and with normals. It is also probable that the defect has been bred out in Set II of the fourth generation though the data in this case is, because of the short period during which these animals were mated, far from conclusive.

To summarize the material contained in Sections III, IV, and V:

The defects present in the first generation are, in general, transmitted to the second and third generation.

All doses administered for long periods have a markedly deleterious effect on the offspring. This effect is present to some degree in the second generation and to an even greater degree in the third. It has bred out by the fourth generation.

Small doses administered for short periods have either no effect on the progeny or are actually beneficial.

Some stocks have bred out through total sterility. No 2¼ c.c. animals produced offspring. These were, therefore, eliminated in the first generation. Only one 2 c.c. animal, a male, had young which survived and these were by a normal female. All of the four surviving offspring were sterile. This stock was therefore eliminated in the second generation. The three surviving young of ¼ c.c., 6 months parents, were also sterile and were eliminated in the second generation.

Sets VI and VII, 2nd generation, and Sets IV, V, and VI, 3rd generation, were born too late in the last year during which this experiment was in progress to make any extensive tests of fertility possible.

In some cases the defect in the stock has been bred out through partial sterility. This has probably occurred in the case of Sets IV and VII, 2nd generation and Sets I and II, 4th generation. Set IV were born of a mating between two ¼ c.c., 4 months animals, and Set VII of a mating between a normal female and a ½ c.c., 4 months male, Set I, 4th generation, came from ½ c.c., 5 ½ months stock and Set II of ¼ c.c., 39 days stock. We have only anatomical evidence to cite in the cases of Sets IV and VII, 2nd generation. Examinations of the generative tracts of alcoholized animals showed, as has been stated, that in no instance were all the spermatozoa of ¼ c.c. or ½ c.c. rats normal, and in many instances the seminiferous tubules were packed with spermatids which degenerated without attaining maturity. Many germ cells were, therefore, eliminated as a result of alcoholism.

As to Set II, 4th generation, the evidence is not conclusive as no extensive tests of fertility were made. It is possible, however, that the improvement in this set may again be due to the failure to function of the less strong germ cells. In the case of Set I, 4th generation, we have a clear evidence that the defect in this stock has bred out through partial sterility. Only one female and one male of this set had young, though attempts were made to inbreed and to cross with normal males and females. Three males and three females of Set I, 3rd generation, were left in the same cage for 6 months; 2 males were left in the same cage with 2 normal females and 2 females of this set were left in the same cage with 2 normal males for three months. No young resulted, though the animals were left together at the mating season. Set I, 4th generation, was therefore the result of some selective process.

It is hardly necessary to point out further the resemblance between animals of the 1st, 2nd, 3rd and 4th generations of the same alcoholized stock, both as to intelligent behavior and as to relative fertility.

Taking into account the results of the examinations of the testicles of alcoholized rats cited in the article previously mentioned i.e.—that headless and tail-less spermatozoa are present in large numbers in the tubules and that spermatids are found in a state of complete arrest and sometimes degeneration, all of which is sufficient evidence that the germ cell itself is affected by alcoholization; and the behavior of our animals, both as to reproductive capacity and intelligent adaptation, the author feels that the results warrant the statement that alcohol can affect a thoroughly healthy stock in such a manner as to produce characteristic changes in the offspring, both as to intelligent behavior and as to degree of fertility. These changes are present, not only in the second generation but also in the third and to some extent in the fourth generations, and are apparently mediated by germinal changes.

VI

CONCLUSIONS

1. Alcohol has a marked effect on the general bodily health of white rats, causing a very slow gain in weight as compared with normals and in some cases an actual loss though the animals were in the growing period.

2. This retardation in growth is inherited by the non-alcoholic offspring of alcoholic animals.

3. Alcohol also has a pronounced effect on length of life. Large doses caused the death of from 74 per cent to 82 per cent of the animals and smaller doses of from 10 per cent to 24 per cent.

4. Large doses of alcohol cause complete sterility, small doses cause a decrease in the number of litters as compared with normals, and of the number of viable young in these litters. Examination of the generative tract of alcoholics gives a clue to the cause of these abnormalities.

5. Alcohol administered for 16 days and 3 months has a deleterious effect upon the speed of running and rate of learning the maze. The effect is roughly in proportion to the size of the dose administered and the duration of the feeding period.

6. Small doses, ½ c.c. and ¼ c.c. per day per rat, fed for 6 months do not effect behavior in proportion to the size of the dose. The smaller dose has a more deleterious effect than the larger. This is probably due to a tendency to accommodate more rapidly to the larger dose.

7. Parental alcoholism results in lessened speed of running and rate of learning the maze when the parental alcoholism has continued for a prolonged period, and in increased speed of running and rate of learning when the dose administered to parent animals has been small and the feeding period short.

8. The effects of parental alcoholism present in the second generation are transmitted to the two succeeding generations, but defects present in the preceding generations tend to breed out by the fourth generation.

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The Form of the Learning Curves for Memory

By

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CONTENTS

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This study was started in the fall of 1915 at the University of Chicago Laboratory and the experimental work was completed in March, 1917, at the Winona State Normal School, Winona, Minn.

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Any one, who has undertaken experimental work with individual human subjects, knows that the main difficulty met with is to find subjects who are willing and can give their time to what to them in most cases must be unprofitable work. I am especially grateful to the graduate students who willingly offered their valuable time at the Chicago Laboratory. I also want to express my appreciation for the kindness of the subjects who so faithfully worked with me at the Winona State Normal School.

I. INTRODUCTION, PROBLEM, AND EXPERIMENTAL PROCEDURE

A very extensive literature has already been developed in connection with various types of learning and learning curves. A good brief summary is found in a recent article by Batson.[1] A somewhat more detailed presentation is given by Thorndike.[2]

A large number of writers have suggested what they call a typical practice curve. Bryan & Harter indicates that the sending curve for telegraphy conforms to the typical form. "The sending curve conforms approximately to the well known typical practice curve with the important difference from the curves usually obtained in the laboratory that it extends over a much greater period of time."[3] This form of the curve is one in which there is a rapid rise at the beginning indicating the rapidity of the learning in the early stages of practice. Later there is a gradual flattening of the curve indicating a progressive decrease in the speed of the learning until a point is reached where the curve is parallel with the abscissa due to the fact that a limit of improvement has been reached.

Swift, on the other hand, seems to imply that the typical practice curve is one whose form corresponds to the curve obtained by him for practice in tossing of balls.[4] This curve is the reverse of that given by Bryan & Harter. It shows a very slow progress at the beginning and a final rapid rise at the end.

Thorndike, after an exhaustive survey of various types of practice curves, says: "If any one simple form of curve, in addition to the straight line representing no change in rate of improvement, had to be chosen to represent the actual variety of facts with the least possible amount of error, . . . The rapid early rise, diminishing from the start until at the end the amount

[1] W. H. Batson, Psych. Rev., Mon. Sup., 1916, No. 91.

[2] E. L. Thorndike, The Psychology of Learning, Columbia University, New York, 1913.

[3] Bryan & Harter, Psych. Rev., 1897, Vol. 4, pp. 49 and 51.

[4] Swift, E. J., Am. Jour. of Psych., 1903, Vol. 14, pp. 204-207 and 228.

of gain is infinitesimal, is suggested by a number of practice curves."[5] Thorndike thus seems to agree with Bryan & Harter and suggests that where there is a variation from this form it often is due to a difference in the method of scoring progress. He, however, cautions against accepting any form as definite and indicates that it is possible that curves for some kinds of learning may take the very opposite form.[5]

Batson, after an experimental study of various factors in the formation of the ball tossing curve, says: "The writer believes there is no typical curve for all types of learning."[6]

It would appear, therefore, that the question as to whether there is a typical practice curve is still an open one. Whatever may be said for a typical practice curve, it is certain that variations from any typical form have been found in nearly all cases. This has lead to various attempts to analyze the factors or causes for the forms of the curves. Most of these factors are more or less hypothetical but a brief survey of the principal ones resulting from the most exhaustive and best known studies will be in keeping with the present investigation.

In attempting to explain the causes for the differences between the sending and the receiving curves for telegraphy, Bryan & Harter give four principal factors; complexity, practice, pleasure, and effort.[7] In receiving a message the complexity of the material is greater than it is in sending and the opportunity for practice at a slow rate is far less. Receiving is apt to be more fatiguing and to became a drudgery while sending is a pleasure. Both curves are in a large measure dependent upon the amount and constancy of the effort put forth for their more detailed form. The particular variations in the form of the receiving curve they hold are due to a gradual development of a hierarchy of habits from lower to higher orders.[8]

Swift has carried out a much more extensive study in so far as the variety of problems is concerned. A number of factors

[5] E. L. Thorndike, the Psychology of Learning, Columbia Univ., N. Y., 1913, pp. 255, 257.

[6] W. H. Batson, Psych. Rev., Mon. Sup., 1916, No. 91, p. 85.

[7] Bryan & Harter, Psych. Rev., 1897, Vol. 4, pp. 351-353.

[8] Bryan & Harter, Psych. Rev., 1899, Vol. 6, pp. 356, 361.

are suggested in his discussions differing somewhat with the kind of learning involved. Great emphasis is placed upon what he calls automatization of accumulated material only partially organized or learned.[9-10-11] Lack of interest, attention, and inability to measure progress are given as factors in the form of some of the curves.[9-12] Physical conditions and subjective states are given as momentary factors.[13]

Book, in his study of the curves for typewriting, seems to emphasize the subjective factors as being the principal causes for variations in the form of the learning curves. Lapses in the learners interest, attention, and effort; attention and effort wrongly applied; past experience with material learned; and the number of possible ways or directions for improvement.[14]

Thorndike has summarized the factors of improvement into four groups or conditions: external conditions, such as time of day, length of practice periods, and distribution of practice in general; physiological conditions, such as heat, light, ventilation, drugs, and disease; psychological conditions, such as interest, attention, worry, emotional attitude, and satisfaction; and educational conditions, such as order of material, approval, and criticism.[15] Thorndike shows, furthermore, that the method of measuring progress has much to do with the form of the learning curve and calls attention to the necessity of keeping in mind the method of measuring progress whenever curves from various kinds of learning are compared.[16] In speaking more directly of the changes in the rate of improvement the factors are summarized in terms of hypothetical "bonds" as follows: "We have seen how (1) the number of bonds, (2) and (3) differences

[9] E. J. Swift, Mind in the Making, pp. 209-212, 217.

[10] E. J. Swift, Psych. Bul., 1910, Vol. 7, pp. 152.

[11] E. J. Swift, Studies in Phil. & Psych. by Former Students of C.E. Garman, pp. 309 ff.

[12] E. J. Swift, Amer. Jour. of Psychol., 1903, Vol. 14, pp. 213-14.

[13] Swift & Schuyler, Psych. Bul., Vol. 4, pp. 307-310.

[14] W. F. Book, The Psychology of Skill (Monograph), pp. 99, 100, 155, 157, 161.

[15] E. L. Thorndike, The Psychology of Learning, Columbia University, N. Y., 1913, pp. 193-234.

[16] Op. cit., Columbia University, N. Y., 1913, pp. 255-261.

amongst them in ease of formation and in effect on the score, in combination with the order in which they are formed, (4) differences in the individual's general power to improve the function at different periods of the practice, (5) the relations of changed ease of formation or effect on score existing between the bonds already acquired, or those to be acquired, and any given bond, (6) the weakening of bonds by disuse, and (7) the useless over-exercise of existing bonds may produce changes in the rate of improvement, and how the kind of change that any defined state of affairs of any of these seven sorts will produce can be deduced."[17]

In an experimental study of the form of the curves for typewriting, we showed that differences in the material or type of learning was a factor in the form of the curves produced. Special emphasis was also called to the part played by wrong habits or associations.[18]

The enumeration of factors given above makes it clear that nearly all the studies made on learning do concern themselves with the factors involved in the formation of the learning curve. Yet these factors are more or less theoretical at least in so far as we have any knowledge of just what part is played by each one of them. Little attempt has been made to separate these factors out and experimentally show just what influence they may have upon the form of the learning curve. Bryan & Harter not only started an interest in the study of practice curves but they also pointed out the way or method by which these various factors might experimentally be tried out. Having formulated the hypothesis that a hierarchy of lower and higher order habits was involved in the form of the receiving curve for telegraphy, they decided to test this out experimentally. The habits they had in mind, from lower to higher, were the letter, word, and connected discourse habits. They, therefore, obtained from one subject separate curves for receiving letters, words, and connected discourse and compared these.[19]

[17] E. L. Thorndike, The Psychology of Learning, Columbia University, N. Y., 1913, pp. 279.

[18] C. L. Kjerstad, An unpublished study on the curves for typewriting, p. 85.

[19] Bryan & Harter, Psych. Rev. 1899, Vol. 6, p. 350.

With the exception of one or two studies, no attempts have been made to follow up the method suggested by these early investigators. Thorndike has suggested that it should be possible "to show, if sufficiently ingenious experiments could be devised, just why certain bonds, ..., do result in a certain practice curve."[20] Bair's study of the practice curve may be considered an effort in this direction. He varied the same general practice by introducing slight variations such that he procured simultaneously four different results from the same subject.[21] The latest and only real attempt, besides that of Bryan & Harter, to separate a complex problem of learning into its principal factors is a study by Batson.[22] This study was designed particularly for studying the plateaus in learning curves but the results are of general significance in relation to the form of the curve as a whole. Making use of Swift's ball tossing type of learning, he devised means of successfully separating out three factors in this learning for each of which he obtained separate curves. His experiment includes a study of the effect of a number of factors working simultaneously, the effect of an isolated factor, and the effect of several factors working in succession.

An unpublished study of typewriting curves made some time ago and to which we have referred above deserves mention here.[23] In that study, we used four subjects who had not before touched the typewriter. Each of these subjects practiced for one half hour per day for a period of about three months. Two kinds of practice were carried on. Each subject practiced for ten minutes on a practice sentence and followed this with a practice in taking copy for twenty minutes. Thus two practice curves were obtained from each subject. In a comparison of these curves, one outstanding fact was the lack of correlation between the two curves of each individual subject, and opposed to this the very

[20] E. L. Thorndike, The Psychology of Learning, Columbia University, N. Y., 1913, p. 280.

[21] J. H. Bair, Psych. Rev., Mon. Sup. 1902, No. 19, p. 28.

[22] W. H. Batson, Psych. Rev., Mon. Sup. 1916, Vol. 21, No. 91.

[23] C. L. Kjerstad, 1916, An experimental study of the form and fluctuations of the learning curves for typewriting (Unpublished), University of Chicago Library.

striking correlation between the practice sentence curves for the four subjects and also the striking correlation between the copy curves of the four subjects. These results were suggestive in that they indicated the possibility of changing the form of the curve by introducing various external factors.

These attempts suggest that the effect of various factors ultimately may be worked out by so altering the experiments or the problems that factors present in the formation of one curve are not found in another. It is clear that here is an open field for a great deal of work which as yet has only been initiated. It is this possibility of experimentally altering the factors involved which has led to the present study.

We found it necessary, however, to limit our problem to one particular type of learning or learning curve. The survey of the studies made on learning curves indicates that the majority of these have involved some form of motor skill. A number of studies have also been made, to determine the effect of practice upon memory, the results of which have been represented by curves. In all of these investigations the main purpose has been to study the improvement that could be made in the time or in the number of repetitions required for memorizing certain groups of material.

On the other hand, no attempt seems to have been made to find out under varying conditions what relative amounts of a certain group of material will be reproduced after each particular repetition or at different stages during the learning until the group as a whole has been reproduced. The present investigation, therefore, is limited to experimentally test out some of the factors which may be involved in determining the form of memory curves or the learning curves for memory. In other words it is an attempt to determine whether or not, by changing certain factors or conditions in a certain group of material, variations may be produced in the percentages mastered at various stages in the learning. To illustrate: Suppose the percentages mastered at six equal intervals in the process of learning should be in order from first to last, 30, 25, 20, 10, 10, and 5. Could this order be changed by varying certain factors such that the percentages would be 10, 20, 30, 25, 10, and 5 or some other order. Only a few of the possible factors, which might be concerned in the form of these curves, could be included in this particular study. The following list is not exhaustive but is suggestive of the large number of possible factors that may effect the form of a learning curve for memory; viz. practice, individual subjects, number of repetitions, kinds of material, length of material, warming-up, fatigue, time of presentation, time for reproduction, method of presentation, method of reproduction, method of measuring progress, interest, attention, effort, inhibition, and the distribution of effort.

Statement of the problem.—This study concerns itself more directly with the form of the learning curves for memory. The purpose is to determine, whether or not, under varying conditions a definite per cent of a definite group of material invariably will be reproduced at certain definite intervals or stages during the progress of the memorizing or learning. In other words, it is an attempt to find out what changes, if any, may be produced in the form of the learning curves by experimentally varying certain factors that may be involved.

Since it would be next to impossible to extend this particular study over all possible factors the following have been selected for the present investigation: viz., to study the effect of (1) practice, (2) individual differences, (3) changes in the kind of material, (4) changes in the length of material, (5) changes in the time of presentation, and (6) certain momentary subjective factors which we have called warming-up and ennui but which may involve interest, attention, effort, and other factors.

Incidentally the number of repetitions required for mastering various lengths and kinds of material has received considerable attention in our results and discussions, due to the fact that our results did not agree with those of some of the best known studies of this phase of the problem.

The Apparatus.—All the material learned by the subjects in this experiment was presented visually by means of a "memory exposure apparatus". This was the ordinary drum apparatus used at the Chicago Laboratory, slightly modified to serve our specific purpose. This apparatus consisted of a revolving drum which was placed horizontally between two standards or supports about eight inches long fastened to a base about eight by fifteen inches. Upon this drum could be attached the sheets of white manilla board upon which the syllables or other materials to be learned were typed. In front of the drum was an aluminum screen with a long aperture about one half an inch in width which could be closed as much as desired by means of shutters from either side. The whole apparatus was placed upon an ordinary study table when in use. The drum was revolved by hand, the operator timing the exposures of the syllables or pairs of syllables presented. At the suggestion of Dr. Carr, an attempt was made to attach a motor to the apparatus. The complicated timing mechanism necessary made this somewhat difficult, so that it was not perfected until several months after the experiment was well under way and it was decided to complete the experiment with the hand apparatus rather than to complicate matters by using the motor apparatus for a part of the experimental work.

Materials.—Five kinds of memory materials were used in the experiment: the paired nonsense syllable material, the paired noun meaning material, the serial nonsense syllable material, the paired number-syllable material, and the paired consonant-syllable material.

The Paired Nonsense Material & The Serial Nonsense Material: The nonsense syllables were constructed by making combinations of two consonants and a middle vowel. The actual number of syllables of this kind that can be made from five vowels and twenty-one consonants is 2289. Discarding those in which the first and the last consonants are the same there remains 2268. From these were discarded those which formed meaning words and those which could not be pronounced as syllables. This left 1228 syllables for actual use. In the experiments, the series were so arranged that a subject was always given an entirely new set of syllables. No syllable was used more than once in any connection for the same subject. From these syllables, selected at random, the paired nonsense material, consisting of series of various lengths of pairs of syllables, was made up; likewise the serial syllable material consisting of single columns of nonsense syllables of various lengths.

The Paired Meaning Material: This consisted of paired monosyllabic nouns. 1747 of these nouns were picked from Webster's Unabridged Dictionary and, like the nonsense syllables, written on little cardboard tickets which were mixed in a box from which they were selected at random. Only nouns were used in order that the material might be more uniform. It is, of course, clear that uniformity of a group of nouns can only be relative, depending upon the individual subject almost as much as upon the material. Monosyllabic nouns were used in order that they might correspond to the nonsense material in all respects except that of meaning.

The Paired Number-syllable Material: This consisted of three place numbers paired with nonsense syllables. Three place numbers were used to correspond to the three elements of the nonsense syllables. Six hundred forty seven such numbers were prepared and selected at random for use in the series.

The Consonant-syllable Material: This material was made to correspond to the number-syllable material. Three place consonant syllables were used in place of three place numbers. Only a very small amount of this material was prepared and used.

Experimental Procedure

For the Paired Nonsense Material: In the experiments in which this material was used, the syllables were arranged in pairs and typewritten on the sheets of soft white manilla board. Where the two syllables together made sense one of them was discarded. The series made up from the first syllables of each of these pairs may be called the test series and the other the associate series. Following the paired series on the same manilla board sheet the test series was written again, so that it could be turned to immediately after the paired series had been exposed. However, the order of the test series in the new position was changed so that the subject could not recall the pairs by reason of the temporal order.

The changed order of the test series was made according to an arbitrary rule but this is so complicated that it would not be worth while to state it here. In place of it, we give in the following illustrations the order in the various lengths of materials used in our experiments. The figures in the first line represent the original order while those in the second line represent the same syllables as they appeared in the new order.

Twelve Pairs														
Original Order =	1	2	3	4	5	6	7	8	9	10	11	12		
New Order =	7	9	4	8	10	5	12	3	1	11	2	6		
Eighteen Pairs														
Original Order =	1	2	3	4	5	6	7	8	9	10	11	12	13	14
New Order =	10	12	14	16	18	1	13	5	17	7	15	3	11	8
	15	16	17	18										
	6	14	2	9										
Twenty-Four Pairs														
Original Order =	1	2	3	4	5	6	7	8	9	10	11	12	13	14
New Order =	13	15	4	19	8	23	1	16	5	20	9	24	11	22
	15	16	17	18	19	20	21	22	23	24				
	7	18	3	14	10	21	6	17	2	12				
Thirty-Six Pairs														
Original Order =	1	2	3	4	5	6	7	8	9	10	11	12	13	14
New Order =	19	21	4	25	8	29	12	33	16	20	3	24	7	28
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	11	32	15	36	17	34	13	30	9	26	5	22	1	35
	29	30	31	32	33	34	35	36						
	14	31	10	27	6	23	2	18						

It is evident that this scheme of rearrangement was rather complicated but it seemed to serve the purpose of successfully keeping the subjects from guessing where to look for any particular test syllable. The purpose was to make the subject depend upon the association between the two members of each pair without attempting any connection with members of other pairs in the series.

Definite instructions were given to the subject at the first sitting. The subject was seated facing the aperture in the screen and told that twelve, or whatever the number of pairs of syllables happened to be, would be successively brought to view in the aperture one at a time. "Each syllable consists of a middle vowel and two consonants. Each of these pairs will be exposed for a period of three seconds. As each pair comes to view you may vocalize it in a whisper if you wish, but always keep your eye and attention on the pair in the aperture even though you are positive that you already have learned it. You should try to associate the two syllables such that when later the first one is presented you can reproduce the second. In doing this you are free to use meaning or any other method you may hit upon. These pairs must not be thought of during the presentation except when they are visually before you. As soon as one pair drops from view and the next one is presented place your whole attention at once upon the new pair. As soon as all the pairs have been exposed the test series will be given. This series consists of the first members of each pair; these are, however, presented in a different order from that in the first exposure. As each of these are presented, five seconds will be given for reproducing the missing associate. If the associate or a part of it comes to mind write it on the paper provided. If in your judgement no syllable that you can think of is the correct associate, indicate this with a dash. Three minutes intermission will be given between the attempted reproduction and the next re-exposure of the series. During this time you should keep your mind off the series all together. The presentations will be continued until you can correctly reproduce all the associate syllables."

These instructions were always made clear to the subject before any presentation was attempted. Parts of the instructions were repeated each day until we were sure that the subject followed them as carefully as he could.

The same instructions were given and the same procedure followed in the paired meaning, the number-syllable and the consonant-syllable material, as in the paired nonsense syllables, except that the difference in the material was made plain to the subject.

For the Serial Nonsense Syllables: In the use of this material the instructions and procedure had to be somewhat different. The subject was told that these were series of single syllables. These syllables would be presented one at a time for three seconds, but he was permitted to spread his attention to any syllable or group of syllables during the presentation. When all the syllables in the series had been presented the subject was asked to reproduce in writing as many as he could, giving them in the order presented if possible. After this the series was presented again. The presentations were continued until all the syllables were correctly reproduced in the order given. In these series it was not possible to limit the subject's time for reproduction. They were, therefore, permitted to take their own time but with the knowledge that they were being timed. While in the paired series the time given for reproduction was five seconds for each syllable, the average time taken for the serial syllables ranged from three to ten seconds. It was quite uniform for each subject and each kind of material.

In General

In all the experiments from five to six sittings per week were given as regularly as possible and at the same hour of the day for each subject. Exceptions to this, unfortunately, did occur at times; since it is impossible to impose upon human subjects any absolute routine. This, unfortunately, is one of the difficulties for the experimenter who undertakes to work with human subjects. As far as our results are concerned, however, the irregularities were not serious; in fact we doubt if any differences in the results did occur.

Subjects.—Subjects A, B, D, E, F, G, H, I, K, and R were all graduate students working in psychology. All of these were men except subject E. Subject C was a graduate student in history, and subjects L, M, N, O, P, Q, J, S, T, and U were primary teachers and normal school students. With the exception of C, J, and T these subjects were women.

Data.—In this study the nature of the problem made us depend upon the objective data as given by the subjects. The subject had to give his whole attention to the task before him without attempting any introspective observations as to what was taking place during the progress of each day's experiment. Certain introspective data were, however, incidentally obtained at the end of each sitting which in some cases aided in the interpretation of the results obtained. These were as a rule entered with the typewritten copy of the objective data from each subject for each sitting. The data consisted of a copy of the material to be learned, the name of the subject, the date and the hour of the experiment, the number of repetitions required for complete reproduction with the actual material reproduced by the subject in each attempt. Where the time was not otherwise controlled by the experiment this was entered for each attempted reproduction.

II. METHODS OF SCORING, COMPARING, AND PRESENTING RESULTS

Sec. 1. A New Method for Scoring Materials Learned

In dealing with the materials or results from our subjects, one of our first difficulties was that of assigning values to the material reproduced. Where the subjects reproduced words, syllables, or numbers correctly the scoring was simple, but where only parts of these were reproduced it was much more difficult. Other elements, such as position of syllables and position of letters and figures, made the problem still more complex and difficult.

Numerous experiments have been conducted using materials somewhat similar to those used in our experiment but very few attempts have been made to arrive at a scientific scoring of these materials and their elements. It is possible that the arbitrary means of scoring served the purpose just as well for their particular problems. In our problem, where we were constantly considering amount of material mastered at progressive intervals in the learning a correct method of scoring became very important, in fact, absolutely essential.

The only article in the literature dealing exclusively with this question is one by D. O. Lyon entitled; A Rapid and Accurate Method of Scoring Nonsense Syllables and Words.[1]

Unfortunately this method, like all other methods with which we are acquainted, is nothing more than an arbitrary assignment of values. The following quotation will serve as a brief statement of the method as it concerns nonsense syllables: "Briefly stated, the method for nonsense syllables was as follows: Each correct letter provided the syllable was in the correct position received a score of one, and the syllable received an extra score of one for being in the correct position. Thus a perfect syllable received a mark of four while a syllable correct in itself but not correct in position received a score of only three. If two of the

[1] D. O. Lyon, Amer. Jour. of Psych., 1913, Vol. 24, pp. 525-531.

three letters of the syllable were correct but the position of the syllable itself were not correct, it was not scored at all. Therefore unless the position is correct the separate letters do not count at all unless all are correct."

The rapidity of this method can not be doubted but its accuracy may well be questioned. No reason is given for assigning these values to the different parts or elements of the syllable. They seem to have been assigned for no other reason than ease and convenience. One might be justified in concluding that because a method is simple and easy, presto it is rapid; but hardly, presto it is accurate. Is there any reason why the same value should be given to the position of a syllable as to one of its letters? If we assume that the mastery of the position of a syllable presents the same difficulty to the mind as the mastery of a letter, yes. Again, is there any reason why the same value should be assigned to the first consonant as to the vowel, or to the vowel as to the second consonant? If we assume that each of the three letters of the syllable presents equal difficulty to the mind, yes. Thus if we are correct in assuming that the mastery of each of these four elements presents equal difficulty to the mind, then the method used by Lyon might be accepted as accurate provided again that these are the only elements involved. However, Lyon, himself, finds that there is one element not comprised within his original scheme, i.e., the position of the letter in the syllable. He finds cases in which the consonants of the syllable are reversed in their position and to this syllable, if correct in every other respect he assigns a value of two. This means that if the consonants of a syllable are reversed, he assumes that the syllable is only half learned or mastered. In other words it is as difficult for the mind to master the position of these two consonants as all the other elements combined. How can the value of two be assigned to the position of these consonants when each element plus the position in his original scheme is given a value of only two and the whole syllable a value of four?

From the point of view of mere chance the assigning of the same value to the vowel as to the consonant seems a very questionable procedure. Since there are only five vowels the chances are that this element of the syllable will be correct one out of five times on a mere guess, while for the consonant it will be correct in only one out of twenty-one times. Were we to score the elements of the syllable on this basis we should have to give the vowel a far lesser value than the consonants. We are, however, not dealing with mere chance but rather with inborn and acquired habits of mind which do not necessarily follow any such simple mathematical formula.

Some other basis must be found upon which to fix the relative values of the different elements in the syllable. This basis, we think, can be found in the relative difficulty encountered by the mind in their mastery. If we should find that the mastery of the position of the syllable presents the same difficulty to the mind as the mastery of each of the letters then we should have reason to assign to it the same value. If it be found equally difficult for the mind to master or reproduce each of these various elements then the method used by Lyon might be correct. If, however, it be found, for instance, that the first consonant presents greater difficulty than the last, the last consonant than the vowel, and the vowel than the syllable position, then his evaluation can not be accepted as accurate. Suppose a man were given the task of climbing four poles, one with spiked steps, one rough, one smooth, and one smooth and greased; he would not be rash enough to say that when he had climbed the spiked pole he had mastered one fourth of the task. The task cannot be measured merely in terms of the number of elements involved; their relative difficulty must be taken into consideration.

But how are we to arrive at so vague a thing as the relative difficulty to the mind of each element of a syllable? This might at first thought be considered next to impossible. We believe, however, that the basis for the measure of such difficulty may be found in a study of the errors made due to each of the elements involved. If we should find that the cause of the syllable being wrong is due in one half of the cases to the interchange of the consonants and the other half of the cases to one or more other elements then the difficulty of mastering the position of the consonants would have to be equal to that of mastering the other elements. If this were true Lyon's scoring of the position of the consonants would be correct. Again if we should find that the cause of the syllable being wrong is due to the incorrect vowel in ¼ of the cases, to the incorrect first consonant in ¼ of the cases, to the incorrect last consonant in ¼ of the cases, and to the incorrect position of the syllable in ¼ of the cases, then it would seem that these four elements represent equal difficulties and each of these should be given the same value in the scoring of the parts of the syllable. If these were the facts in the case, then we could accept the values given by Lyon to the letters and the position of the syllable as accurate.

With these possibilities before us we are prepared to inquire into our own results. We will take up first of all the paired nonsense material more or less in detail after which we will study the other kinds of material in relation to this.

The following table (Table I), was obtained from the results of 126 series of twelve pairs each, representing results from nine different subjects. The column marked S represents the number of series for each subject; V the number of times the syllable is wrong, due to errors in the vowel, 1C to the errors in the first consonant, 2C to errors in the last consonant, and P to the errors in the syllable position. The error in each case was either an omission or a substitute for the correct element. The interchange of the first with the last consonant occurred once or twice for most of the subjects but these were not numerous enough to be taken into consideration.

TABLE I

The Number of Each Kind of Error for Individual Subjects

Subject	S	V	1C	2C	P
A	26	30	54	86	96
B	26	15	46	99	39
C	20	31	59	78	41
D	12	3	14	32	12
E	6	5	7	11	8
F	6	9	13	27	12
G	6	13	13	30	6
H	8	12	23	14	13
I	16	33	43	81	13
Totals	126	151	272	458	240

Comparisons, of the number of errors due to the various elements and for the different subjects, present some very interesting facts. It should be remembered that the possible number of errors is the same for each of the elements, excepting the vowel, for each subject, when measured in terms of chance. In spite of variations for each element and subject, the table presents considerable uniformity in several respects. Taking the three letters of the syllable, we find that in every case the vowel is the cause of the least number of errors, the first consonant comes next for all subjects except H, and the last consonant is the greatest offender of all for all subjects except H. Whether with an increase of the number of cases H would have tended to conform to the group we can not tell. The difference may be due to a peculiarity in the method of learning. The relative number of times that the syllable is wrong due to error in position is not so uniform, yet it is sufficiently so to be noticeable. For five of the subjects the number comes between that of the vowel and the first consonant, for two subjects it falls below that of the vowel, for one between the vowel and the last consonant, and for one above that of the last consonant. The total for all subjects naturally falls between the first consonant and the vowel.

From the totals of all cases the number of errors from less to greater arrange themselves in the following order: vowel, syllable position, first consonant, and last consonant.

It occurred to us that the order might possibly change with practice. The fact, that the order for the subjects who had twenty-six series is the same as that for those who had only six, is, however, in itself evidence that the order is a constant. In order to test this hypothesis further we constructed the following table (Table 2), from the errors of the three subjects who had twenty or more series. The table gives the number of errors for each element for the first half and the last half of each subject's work.

TABLE 2
Number of Errors for the First Half and the Second Half of Each Subject's Practice

Subject		V	1C	2C	P
A	1st Half	25	35	52	65
A	2nd Half	5	19	35	32
B	1st Half	5	26	51	22
B	2nd Half	10	20	48	17
C	1st Half	20	35	44	25
C	2nd Half	11	24	34	16

The table shows that there is some variation in the number of errors in each case yet the relative position for each element is the same for each half as it was in the first table.

In the following table, (Table 3), the totals from the 126 series of the twelve paired series is compared with the total errors due to each element from longer paired syllable series. (Series were 24, 18, and 36 pairs in length, given to six different subjects.) The errors due to each element still hold the same relative position as to numbers as in the twelve paired series.

TABLE 3
Relative Number of Errors for Materials of Various Lengths

	S	V	1C	2C	P
12 syllable series	126	151	272	458	240
18, 24, and 36 syllable series	26	72	102	141	64
Totals	152	223	374	599	304

From our results thus far, it appears that we almost invariably get the same order, i.e., V, P, 1C, and 2C, for all the paired nonsense series. If we remember that the possibility of errors is the same for all elements, i.e., there are an equal number of vowels, consonants, and positions concerned, then we may conclude from the above results that in the case of the paired nonsense material learned as in our method of procedure, the mind finds least difficulty in reproducing the vowel element, greater difficulty in reproducing the syllable position, still greater difficulty in reproducing the first consonant, and the greatest difficulty in reproducing or mastering the last consonant of the syllable. The results indicate further, that, although the advantage is with the vowel, it is not nearly so great as one might suppose from the chance advantage it would have in a mere guess compared with the consonants. Again we find that if we add the number of errors due to the vowel and first consonant we get a sum of 597 as compared with 599 for the last consonant. That is the last consonant is the cause of error as often as the vowel and the first consonant combined.

In the following table, (Table 4), are given the totals in errors due to the various elements of different kinds of materials. A represents the paired nonsense already discussed; B the serial nonsense material; C the numbers paired with nonsense syllables; D consonants paired with nonsense syllables; and E the serial consonant material. S represents the number of series or cases; V represents the number of errors due to the vowel, middle figure, or the middle consonant; 1C those due to the first consonant or figure; 2C those due to the last consonant or figure; P those due to the syllable position; EP those due to the element position; and Av. the average number of errors for each series.

TABLE 4

Total Number of Errors for Different Kinds of Material

	S	V	1C	2C	P	EP	AV.
A =	152	223	384	599	304	—	9.89
B =	180	294	284	604	447	—	9.05
C =	66	138	85	160	293	176	13.00
D =	6	8	2	20	76	14	20.00
E =	6	4	4	5	70	3	14.17

Even though it may involve repetition, a word is in place here with reference to the kinds of material from which the above data were taken as well as the method of learning and reproduction in each case.

Series A, C, and D were alike in that they contained one set of association syllables or a cue series. In A these were paired with another series of nonsense syllables, in C with numbers of three figures each, and in D with syllables of three consonants each. In learning, these were presented one pair at a time and the subject was required to keep his attention upon each pair only so long as it was visually before him or until the next pair was presented. He tried to fix the members of each pair in his mind so that when later the cue syllable was presented he could reproduce its associate. Series B were series of serial nonsense syllables and series E three place consonant series. These were presented one at a time visually and the subject was left free to distribute his attention over the series as he saw fit and could series no cue was given except as each syllable reproduced by the subject might be a cue to the one following.

The Serial Series B: Series A have been discussed in detail above. The table, (Table 4), shows that the average number of errors for the B series is almost identical with that of the A series. The relative number for each element is, however, slightly different. The order from less to greater is: first consonant, vowel, syllable position, and last consonant. The last consonant is again the greatest offender, while the vowel and the first consonant are almost on a par. As in series A, we find that if we add the number of errors due to the vowel and first consonant we get a sum which is no larger than the number due to the last consonant alone. Just why there should be relatively less errors due to the first consonant in the unpaired series, we are not prepared to say. No doubt the method of learning and the method of reproduction are responsible for the change. Possibly certain motor and kinaesthetic factors involved in the B series may give rise to greater emphasis upon the first consonant and thus lessen the relative proportion of errors for it.

Series C, D, and E. (Numbers and Consonants). In these series the loss of the vowel element gives rise to certain changes. In the first place the average number of errors is increased. A new factor, the position of the element, figure or consonant, enters. The figures or consonants are often interchanged or placed in the wrong position. The first consonant or figure now takes the place of the vowel in that it gives rise to far less errors than any other element. In these series the order is: first figure, second figure, third figure, element position, and syllable position. In the D series the element position comes before the last figure and in the E series it comes before the second figure which corresponds to the vowel.

Summary

1. Errors in the reproduction of nonsense syllables may be due to any one of four elements: the vowel, the first consonant, the last consonant, or the syllable position.

2. The vowel in a nonsense syllable is relatively the cause of less errors than any other element, yet it is relatively the cause of more errors than would result from mere chance or guess.

3. The last consonant of the syllable is relatively the cause of

more errors than any other element and is the cause of as many errors as the vowel and the first consonant combined.

4. The average number of errors for each series of nonsense syllables reproduced remains much the same whether controlled cue associations are used or the serial syllables in which the subject is given more freedom both in learning and reproduction.

5. Where the three elements of the syllable are identical in kind, as figures or consonants, a new factor the element position enters as a cause of error.

6. The order from less to greater in the cause of error is as follows in the various kinds of material:

	1	2	3	4	5
Paired Nonsense Syllables = - -	V	P	1C	2C	—
Serial Nonsense Syllables = - -	1C or	V	P	2C	—
Paired Nonsense Syllables & Numbers =	IC	V	2C	EP	P
Paired Nonsense Syllables & Consonant Syllables =	1C	V	EP	2C	P
Serial Consonant Syllables = - -	EP	1C	V	2C	P

7. The most significant result from this whole study is the invariable fact that where the *three* elements of the syllable, be it numbers or consonants, are of the same kind the order in the cause of error from less to greater is always from first to last or from left to right. Our results show quite conclusively that the human mind, be it from innate nature or from training or both, grasps and reproduces most easily the first or left hand element and with greatest difficulty the last or right hand element of a syllable or a number of three figures. This is in part contrary to the well known fact that in memorizing a group of syllables or other material the first and last parts are mastered before the parts in between. Our results thus tend to show that in the learning of nonsense syllables or numbers the same law does not hold true for parts or elements of the individual syllable or number. Here the first part is learned first and the last part last as measured in terms of the number of errors.

8. The results from our study, it appears, show that it is possible to make the errors a basis for scoring of the various parts or elements of a syllable or number. The facts produced support our theory that the errors are a function of the difficulty of the various elements in the syllable or number. The relative diffi-

culty encountered by the mind in mastering each of these elements may thus be measured in terms of the relative number of errors caused by each element and thus be made to represent the relative value or score of each part or element.

It is evident that the values will apply only to the specific kinds of material for which they are worked out. The principle, however, is applicable to nearly all kinds of material; such as parts of geometric figures and runways and alleys of the maze. Our results show, however, that the scores given to the elements by the method used by Lyon are not accurate. The relative values, according to our results can not be identical for the different elements.

Values Used in Scoring.—We found that in the case of the paired nonsense series the syllable elements are the cause of error in the following order from less to greater: V, P, 1C, 2C. This means that the vowel is the least difficult to master and should consequently be given the least value, then in order of value should come the syllable position, the first consonant, and finally the last consonant which should be given the greatest value. In the case of the serial syllables the order of value should be, from less to greater: first consonant, vowel, syllable position, and last consonant. For the numbers it should be: first figure, second figure, third figure, element position, and syllable position.

Using the total of errors due to each element as a basis, the per cent of error can be determined and this will then be a measure of the relative difficulty of each element and may thus be made to represent its relative value.

The following tables show the relative number of errors, E; the relative percent of error, %; and the relative value, RV; which were assigned and used in our scoring.

TABLE 5

Paired Nonsense Syllables

	E	%	RV
V =	223	14.8	3
1C =	384	25.4	5
2C =	599	39.7	8
P =	304	20.1	4

TABLE 6

Serial Nonsense Syllables

	E	%	RV
V =	294	18.1	2
1C =	284	17.4	2
2C =	604	37.1	4
P =	447	27.4	3

TABLE 7
Numbers Paired with Syllables

	E	%	RV
Fig. 1 =	85	10.0	1.0
Fig. 2 =	138	16.2	1.5
Fig. 3 =	160	18.7	2.0
P =	293	34.5	3.5
EP =	173	20.6	2.0

TABLE 8
Consonant Syllables

E	%	RV
5	3.0	1.0
12	7.0	2.5
25	15.0	5.0
111	65.0	21.5
17	10.0	3.5

TABLE 9
Paired Meaning Material

	E	%	RV
Position =	35	40.0	2
Substitution =	53	60.0	3

The relative values worked out for the consonant syllables are based on too few cases, i.e., only twelve, to be entirely satisfactory. The high relative value for the syllable position may be questioned; yet there is no doubt but that it should be higher than in the case of the other materials. The mind naturally would find it more difficult to associate three consonants with a syllable, since they lack entirely the unity possible for three figures or two consonants and a middle vowel.

In the case of the meaning material, where words are learned as unit wholes, we did not expect to find any other errors but those of position. Upon careful study of the material two kinds of errors were found. One was that of position, P; the other was that of substitution, S. This last error, as may be seen from Table 9, was the most common. This error consisted in substituting for the correct word a word similar either in meaning or in sound. The table shows the total number of errors of each kind found in the results from our subjects with a total of 58 series of cases. It is clear from the table that the errors in this material were extremely few as compared with those of other materials. In most cases the subject either reproduced the correct word or else he failed to give anything.

In our scoring we have based our relative values upon the actual number of errors produced by each element considered and neglected other possible factors. Our purpose has been to get a valuation that would not involve too complicated a procedure and yet be accurate enough for practical purposes. We have at least arrived at a valuation more accurate than any based upon mere guess or upon pure chance possibilities. It is clear that the method of scoring syllables and parts of syllables will modify the results in no small degree, especially where the number of errors is large.

We have used in this thesis the scores which we have given above. They represent the values of syllables and elements of our material as nearly as they can be derived on a scientific basis.

Sec. 2. Methods of Grouping, Comparing, and Presenting Results

Another difficulty which presented itself was that of grouping, comparing, and presenting the results of our experiments in some intelligible fashion.

As already indicated, several curves were obtained from each subject. Some of these were the result of twenty-five or more trials or repetitions; while others, especially after practice, required only six or even less repetitions for learning the material given. Obviously we could not do as has been done in some experiments on animals in which the same number of trials were given to each animal. We had to limit the number of presentations to those required for the first accurate reproduction of the material whether it took five or thirty repetitions.

Dr. Vincent, in connection with experiments on white rats, calls attention to the unfairness of giving the same number of trials to all animals, no matter whether they master the problem in few or many trials.[2] She points out that a problem is learned "when it can be performed relatively free from error whether it takes ten or forty trials." She, therefore, adopted a method as follows: "In this experimental work an animal's trials were discontinued when the problem was learned or one period beyond such time. The numerical results of time and error for each animal were then divided into an equal number of serial groups, say ten, regardless of whether in the learning he had taken twenty of forty trials. In the one case there would be two numbers in each group and in the other four. The averages were then taken by groups and thus there was obtained for each animal a series of ten numbers. If there was an excess it was always distributed among the beginning group." In other words, Dr. Vincent

[2] Vincent, E. B., Behavior Monographs, 1912, Serial No. 5, pp. 16, 17.

grouped trials by twos, threes, or fours as the case might be. The averages of these were taken and thus a group curve obtained.

This procedure is a decided improvement in method and might be accurate enough for some problems and for work on animals. Our problem and purpose was, however, somewhat different. In our results the excess or odd numbered trials or repetitions would not be sufficiently distributed by this method. Furthermore, we wanted to compare, not only different curves, but different stages of learning in the same curve. For this reason the following method was devised: Every individual curve was accurately drawn on cross section paper provided for this purpose. This curve accurately represents the progress of the subject until complete reproduction resulted. Having the curve, it is possible to select any point on it and get the percentage reproduced at that point. All one needs to do is to take any point on the base line and follow the vertical line from this point to the point where it intersects the curve. The distance of this point from the base line indicates the percentage reproduced at this stage of the learning. It is thus possible to tell in a moment how much of the problem the subject has mastered in halves, thirds, sixths, tenths, or any other number of divisions one might wish to make.

The advantage of this method for our purpose over that used by Dr. Vincent is two fold. First, it takes care of the odd number of repetitions which by her method were distributed among the first groups. By our method, every trial gets its full value. Second, it permits us in a moment, without calculation, to find the percentage or the part of the problem mastered at any particular stage in the learning.

As has been mentioned before, several curves were derived from each subject for each kind of material. The results given in the following studies are always averages from the individual curves of each subject. The number of curves from which the averages were taken is stated in all our tabulations and ranges from six to twenty-six curves.

The reader may be disappointed in not finding a large number of graphical learning curves on the following pages. In a treatise of this kind, we found it impracticable to use the usual method of graphical representation of the results. This for two reasons: First, on account of their number, it would have required pages and pages of these curves in order to represent the results for each particular study made. It is clear that these would not have been of much value for comparative purposes. The second and most pertinent reason for not using the usual graphical forms of the curves is that, as will be shown later, the curves were found to be so much alike that the graphical method would not at all indicate the differences where they were found.

In place of the graphical representations, we have, therefore, made use of numerical tables. These we found would bring the results into a more compact form for comparison and, furthermore, would show even the slightest variation in the curves. We were interested to know at what points in the curve the learning was most rapid and at what points it was least rapid. To arrive at this, we found the following procedure the most advantageous and it has been followed throughout all our studies.

Tables were made from the curves giving the percentages reproduced in successive halves, thirds, and sixths. These various points on the curves were thus represented in figures and in this way comparison of the various curves are possible by comparing these particular points in the learning. Likewise, it is possible to get averages of these points and thus get averages from a group of curves which are comparable in the same way. It would, of course, have been possible to take still other points in the curves than those taken but the comparisons would have been made more difficult and the value of the additional details would have been slight.

For general purposes, this method should also be of value. These figures can be compared with those from halves, thirds, and sixths of any other curves and of any kind of problem from which they may be derived.

The tables will be described in greater detail in connection with each of the studies made. Besides the percentages reproduced in halves, thirds, and sixths there will be found in each table the number, or in some cases the average number, of repetitions required for complete and accurate reproduction; as well as the number of cases from which the averages were taken.

III. EXPERIMENTAL RESULTS

Sec. 1. Practice Effect. The Effect of Practice Upon the Form of Learning Curves for Memory.

It is a truism among those who have performed experiments on memory that some improvement does occur from practice in memorizing specific kinds of material, in the sense that one can memorize more quickly or with fewer repetitions and with less effort. This fact is due, no doubt, as suggested by James, to improvement in method and "elaboration of associations" for specific kinds of materials rather than to a general improvement of native memory as such.

Our problem here, however, was to determine whether there might not at the same time be some change in the learning curve for memory due to practice. In other words we wished to see whether or not the relative amounts of a certain group of material mastered at different intervals during the learning of that group or rather similar groups, would remain the same after practice. For this purpose we procured, through methods already described, 261 curves from seventeen subjects and for four kinds of material. The curves for each specific material were tabulated separately for comparison.

As would be expected, the individual curves present considerable variation. This, connected with the fact that so many curves could not well be brought together in their original form and compared in any practical way, made it necessary to resort to some other method that would present the main facts in some intelligible fashion. Two methods were adopted to show changes that might occur in the curves: first, by comparing, by means of our general method of tabulation described above, averages of the curves for the first half of the practice periods with averages of the curves for the second half for each kind of material; second, by representing graphically in detail specific points in each of the memory curves from the first to the last in order.

For the paired nonsense material, we used the results of subjects A, B, C, D, E, and F representing 26, 26, 20, 16, 12, and 8 practice periods respectively and a total of 108 curves. (A practice period signifies the time and number of presentations required to learn and reproduce accurately a certain group of material resulting in a memory curve.) For the serial nonsense material, we used the results from subjects L, M, P, Q, and R representing 24, 24, 10, 9, and 12 practice periods respectively or a total of 79 curves. For the meaning material, we used the results from subjects G, H, and I representing 20, 20, and 10 practice periods respectively and a total of 50 curves. For the numbers paired with nonsense syllables, we used the results from subjects N, O, and M representing 8, 8, and 8 practice periods respectively and a total of 24 curves.

A. *Tabulations and Comparisons by Halves of Total Practices*

In making comparisons of averages, we have made tabulations showing the average percentages reproduced by halves, thirds, and sixths of the effort expended for the first half and the last half of the practice periods or curves of each individual subject. Following the tables for the individual subjects for each kind of material, we have a table showing the averages of all the curves for all the subjects for the first half and the last half of their practice periods. Finally we have a table indicating the number of subjects showing an increase and the number of subjects showing a decrease in the averages for the last half of the practice periods.

We can make clear the tabulations, (Tables 10-13), for each subject by taking those of subject A, Table 10, as an illustration. The horizontal row of numbers preceded by A I represents the averages of the first thirteen practice periods or curves of this subject and that preceded by AII the averages for the last thirteen practice periods or curves. The column marked P represents the average number of presentations required for each of the curves, 7.6 for the first half or thirteen and 6.6 for the last half or thirteen curves. In the first column marked 1 the 63.8 represents the average percent reproduced during the first half of the effort expended for the first thirteen curves and 63.6 the average percent for the last thirteen curves. In the first column marked 2 the 34.2 represents the average percent reproduced during the second half of the effort expended for the first thirteen and 36.4 for the last thirteen practice periods or curves. Likewise in the columns marked 1, 2, and 3, we find the percentages reproduced in thirds of the effort expended and in columns marked 1, 2, 3, 4, 5, and 6 the percentages reproduced in successive sixths of the time or effort expended. Thus the results of this subject indicate slight changes in the curve for the last half of the practice periods but with no pronounced changes in its general form. Taking the curves as represented in sixths, we see that the greatest change is found in the second and the third sixths, while there are practically no differences in the first, fourth, fifth, and last sixths. The tables of the other subjects are quite similar to those of subject A.

As the figures stand they represent points in the curve so far above the preceding point and do not indicate the distance from the abscissa or base line. If they were added successively, they would represent points as far above the base line as indicated by their sums. To illustrate, subject A for the first half of his practice periods, i.e., A I, by sixths reproduced 22.1 per cent of the material on the average for the first sixth of his effort, 22.1 thus represents a point in the average curve one-sixth of the distance from the ordinate and 22.1 points above the base line. 28.1 represents the average percent reproduced in the second sixth of the effort and represents a point two-sixths or one-third the distance from the ordinate but 22.1 plus 28.1 or 50.2 points above the abscissa.

Averages from the First Half of the Curves Obtained Compared with Averages from the Last Half. Tables 10, 11, 12, and 13.

TABLE 10

Paired Nonsense Material

		Halves		Thirds			Sixths					
Sub.	P	1	2	1	2	3	1	2	3	4	5	6
A I	7.6	65.8	34.2	50.2	30.8	19.0	22.1	28.1	15.6	15.2	8.4	10.6
AII	6.6	63.6	36.4	41.3	38.1	20.6	20.3	21.0	22.3	15.8	9.2	11.4
B I	8.0	69.2	30.8	44.3	33.6	22.1	18.6	25.7	24.9	8.7	9.8	12.3
BII	5.0	66.5	33.5	42.6	39.5	17.9	19.2	23.4	23.9	15.6	7.2	10.7
C I	9.8	55.6	44.4	35.4	39.2	25.4	18.1	17.3	20.2	19.0	13.4	12.0
CII	7.0	55.0	45.0	35.5	42.4	22.1	16.4	19.1	19.5	22.9	12.8	9.3
D I	9.5	53.8	46.2	31.0	44.7	24.3	12.1	18.9	22.8	21.9	13.0	11.3
DII	8.4	57.8	42.2	36.0	39.8	24.2	15.5	20.5	21.8	18.0	11.7	12.5
E I	5.2	59.8	40.2	37.6	36.7	25.7	14.8	22.8	22.2	14.5	18.2	7.5
EII	4.3	57.1	42.9	31.8	46.3	21.9	15.5	16.3	25.3	21.0	13.0	8.9
F I	5.3	52.6	47.4	33.8	38.7	27.5	15.0	18.8	18.8	19.9	11.9	15.6
FII	5.7	56.1	43.9	35.0	41.0	24.0	11.8	23.2	21.1	19.9	12.0	12.0
Averages												
Curves												
I	54	61.3	38.7	40.6	36.4	23.0	17.8	22.8	20.7	15.7	11.6	11.4
II	54	60.6	39.4	38.2	40.6	21.2	17.4	20.8	22.4	18.2	10.4	10.8
Increase and Decrease												
		1	2	1	2	3	1	2	3	4	5	6
Increase		2	4	3	5	1	3	3	3	4	2	3
Decrease		4	2	3	1	5	3	3	3	2	4	3

Figures in the table of increase and decrease represent the number of subjects showing either an increase or a decrease for the fractional part in the second half.

TABLE 11

		Halves		Thirds			Sixths					
Sub.	P	1	2	1	2	3	1	2	3	4	5	6
L I	9.0	72.2	27.8	53.8	29.8	16.4	35.0	18.8	18.4	11.4	8.3	8.1
LII	5.1	80.9	19.1	58.5	32.5	9.0	34.1	24.4	22.4	10.1	5.0	4.0
M I	5.0	76.1	23.9	54.9	33.6	11.5	32.4	22.5	21.2	12.4	5.8	5.7
MII	5.2	71.1	28.9	53.6	28.0	18.4	28.6	25.0	17.5	10.5	10.4	8.0
P I	6.8	64.7	35.3	52.2	28.6	19.2	31.5	20.7	12.5	16.1	9.9	9.3
PII	3.8	74.5	25.5	58.7	29.7	11.6	34.0	24.7	15.8	13.9	6.6	5.0
Q I	7.0	68.4	31.6	53.0	26.0	21.0	33.6	19.4	15.4	10.6	11.5	9.5
QII	5.4	73.1	26.9	54.6	33.6	11.8	32.7	21.9	18.5	15.1	5.9	5.9
R I	8.7	67.3	32.7	55.4	26.1	18.5	36.3	19.1	11.9	14.2	8.2	10.3
RII	8.2	73.1	26.9	59.8	21.7	18.5	48.0	11.8	13.3	8.4	9.7	8.8
Averages												
Curves												
I	39	71.2	28.8	54.0	29.9	16.1	33.8	20.2	17.2	12.7	8.1	8.0
II	40	74.9	25.1	56.7	29.3	14.0	34.3	22.4	18.2	11.1	7.6	6.4
Increase and Decrease												
		1	2	1	2	3	1	2	3	4	5	6
Increase		4	1	4	3	2	2	4	4	1	2	1
Decrease		1	4	1	2	3	3	1	1	4	3	4

Figures in above table represent number of subjects for whom increase and decrease occurred in the fractional parts.

TABLE 12
Paired Meaning Material

Sub.	P	Halves 1	2	Thirds 1	2	3	Sixths 1	2	3	4	5	6
G I	3.2	67.5	32.5	47.1	38.0	14.9	23.8	23.3	20.4	17.6	7.9	7.0
GII	3.2	65.8	34.2	46.0	37.2	16.8	21.7	24.3	19.8	17.4	9.3	7.5
H I	3.9	71.5	28.5	48.3	38.0	13.7	24.1	24.2	23.2	14.8	7.9	5.8
HII	4.1	78.4	21.6	58.2	29.9	11.9	30.4	27.8	20.2	9.7	6.7	5.2
I I	3.4	77.6	22.4	55.8	31.9	12.3	29.4	26.4	21.8	10.1	6.5	5.8
III	2.4	82.7	17.3	63.0	27.2	9.8	31.5	31.5	19.7	7.5	5.0	4.8
Averages												
Curves												
I	25	71.1	28.9	49.3	36.7	14.0	25.0	24.3	21.8	14.9	7.7	6.3
II	25	74.1	25.9	54.2	32.3	13.5	27.1	27.1	19.9	12.4	7.4	6.1

Increase and Decrease

	1	2	1	2	3	1	2	3	4	5	6
Increase	2	1	2	0	1	2	3	0	0	1	1
Decrease	1	2	1	3	2	1	0	3	3	2	2

TABLE 13
Numbers Paired with Syllables

Sub.	P	Halves 1	2	Thirds 1	2	3	Sixths 1	2	3	4	5	6
N I	13.0	58.2	41.8	42.3	37.2	20.5	27.2	15.1	15.9	21.3	9.3	11.2
NII	7.0	53.9	46.1	38.6	31.2	30.2	24.5	14.1	15.3	15.9	17.0	13.2
O I	17.0	60.6	39.4	37.4	41.3	21.3	23.5	13.9	23.1	18.1	10.5	10.8
OII	9.0	57.4	42.5	39.4	38.4	22.5	21.9	17.5	18.0	20.1	10.4	12.1
M I	12.7	68.5	31.5	46.4	36.1	17.6	28.1	18.3	22.1	14.0	4.1	13.4
MII	9.3	72.2	27.8	52.3	34.7	13.0	34.2	18.1	19.9	14.8	8.5	4.5
Averages												
Curves												
I	12	62.5	37.5	42.1	38.2	19.7	26.3	15.8	20.4	17.8	8.0	11.7
II	12	61.2	38.8	43.5	34.6	21.9	26.9	16.6	17.7	16.9	11.9	10.0

Increase and Decrease

	1	2	1	2	3	1	2	3	4	5	6
Increase	1	2	2	0	1	1	1	0	2	2	2
Decrease	2	1	1	3	2	2	2	3	1	1	1

Figures in the tables for increase and decrease represent the number of subjects for whom either of these took place in the fractional parts for the averages in the last half of the curves.

B. *Graphical Representations of Specific Points in Individual Curves for the Whole Period of Practice*

(Plates I, II, and III)

In order to get a more detailed view of changes in the curves from day to day, graphs have been drawn showing the percentages reproduced for the first, second, third, fourth, and fifth sixths of the presentations or effort expended at each practice period for each subject. Only results of the subjects who had the greatest amount of practice are represented in these graphs.

Nearest the abscissa line in each group of graphs will be found the practice curve, marked P, which represents the effect of practice upon the number of repetitions required to perfectly reproduce the material learned. The number of repetitions are represented on the vertical axis or ordinate and the number of practice periods upon the horizontal axis or abscissa.

The other graphs represent the percentages reproduced at various sixths in the practice periods or curves. Graph I is drawn through the points indicating the percentages reproduced at the practice periods after the first sixth of the time or effort consumed; graph II is drawn through the points indicating the percentages reproduced after the first two sixths or first third of the time or effort consumed; likewise graph III represents the same for the first three sixths or the first half, graph IV for the first four sixths or first two thirds, and graph V for the first five sixths of the time or effort consumed. At the end of the last sixth the points all represent one hundred per cent, hence a graph drawn through them must be a straight line. Percentages are represented on the ordinate and the number of practice periods or, what is the same, the number of memory curves is represented upon the abscissa line. Marked individual variations have been smoothed by using the moving average, taking the numbers by fives.[1] Since this smoothing process left the first two and the last two numbers as they were, we have smoothed these by adding to or subtracting from, as the case may be, the nearest smoothed number one third of the difference between the smoothed and the unsmoothed number next to it. Thus if the numbers were 16, 24, 21, ...; 21 being the first smoothed number the results would be 20, 22, 21, etc.

For the paired nonsense material, we have the graphs for subjects A, B, C, D, and E; for the numbers paired with syllables the graphs for subjects N, O, and M; for the paired meaning material the graphs for subjects G and H; and for the serial nonsense material the graphs of subjects L and M.

[1] King, Elements of Statistical Method, Chap. XV, Sec. 96.

PLATE - I

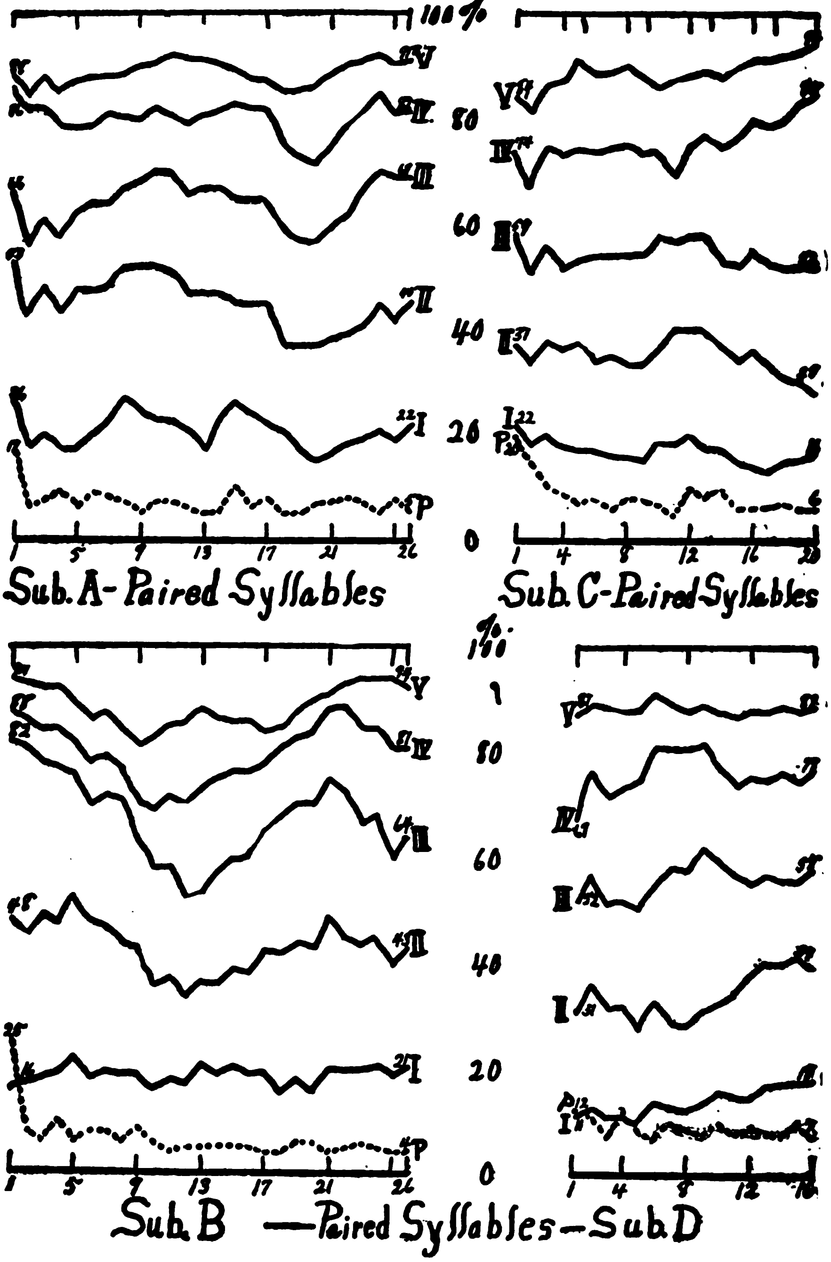

100 %
80
60
40
20
0
Sub. A- Paired Syllables
Sub. C-Paired Syllables
Sub. B —Paired Syllables—Sub. D

PLATE II.

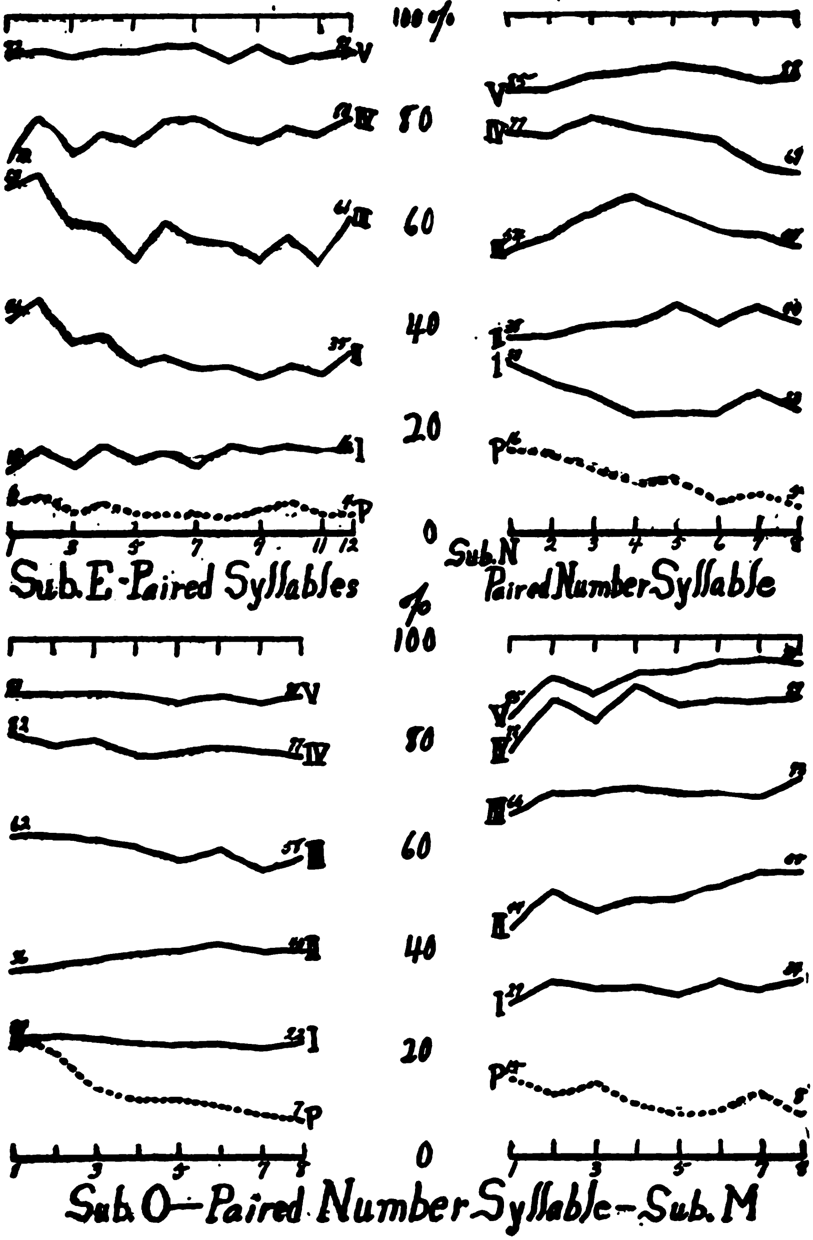
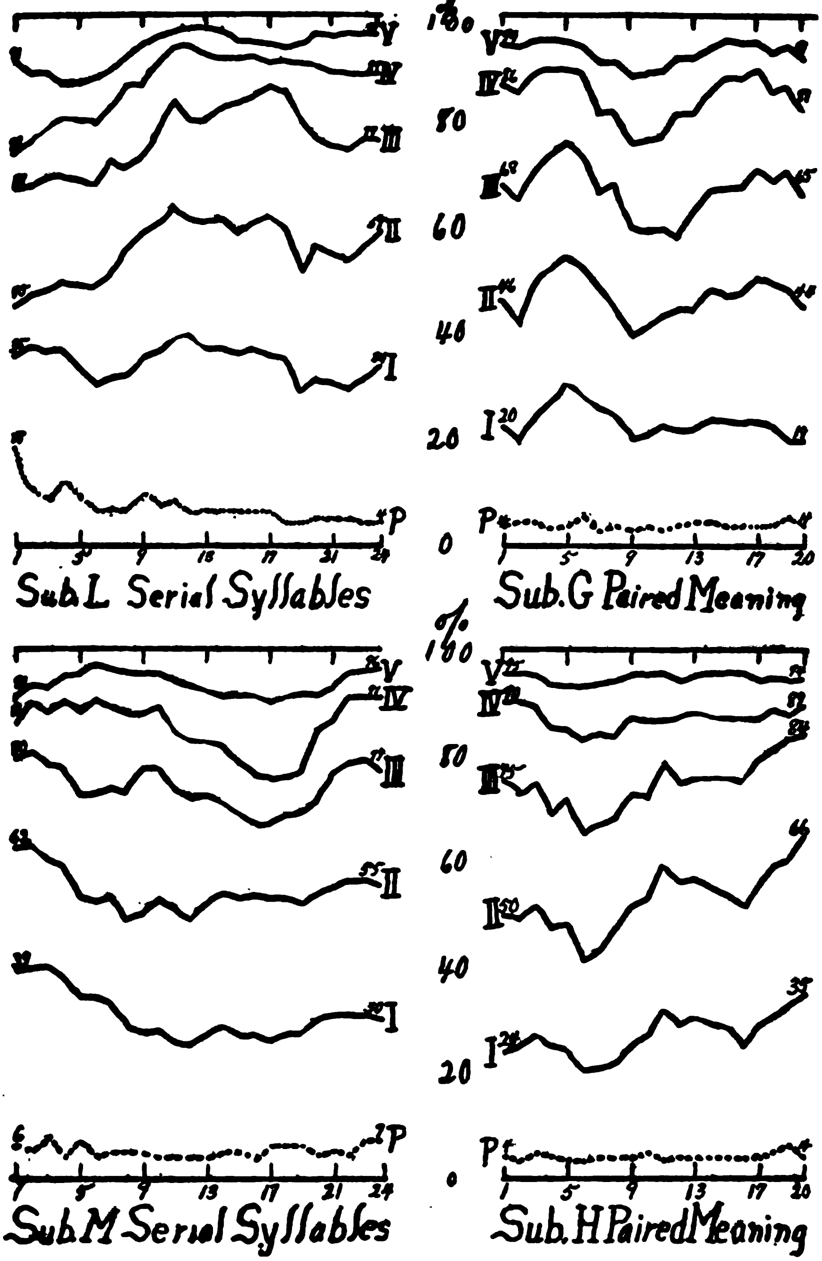

100 %
80
60
40
20
0
Sub. E - Paired Syllables
Sub. N
Paired Number Syllable
%
100
80
60
40
20
0
Sub. O — Paired Number Syllable — Sub. M

PLATE III


Sub. L Serial Syllables
Sub. G Paired Meaning
Sub. M Serial Syllables
Sub. H Paired Meaning
%
100
80
60
40
20
0
V
IV
III
II
I
P

C. *Facts Derived from the Data Above*

(1) The Effect of Practice upon the Number of Presentations or Repetitions required for Memorizing.

A study of the column marked P in the tabulations, Tables 10-13, shows that for most of the subjects there is a marked reduction in the average number of presentations required for the second half of the practice periods in order to get a perfect reproduction of a specific group of material. It is also clear that the amount of reduction depends upon the kind of material practiced upon. In the case of the meaning material, for instance, there is really no reduction at all for our subjects. One shows a slight increase in the last half on the average, one a slight decrease, and one no difference at all. The greatest reduction seems to be found in the case of numbers paired with nonsense syllables. For two subjects the number of presentations are reduced by one half on the average and for one subject by one fourth. In case of the paired and the serial nonsense material, all subjects except one for each group show a substantial reduction in the number of presentations required on the average during the second half of the practice periods. These facts are brought out graphically in greater detail in the P curves found on Plates I, II, and III. The P curves for the paired nonsense material, subjects A, B, C, D, and E, (Plates I and II), all show some effect from practice in the reduction of the number of presentations or reproductions required to reproduce the various materials. The same is found to be true for the number-syllable material, subjects N, O, and M, (Plate II), and the serial nonsense material, subjects L and M, (Plate III). (It will be noted that subject M had practice on two kinds of material. The practice on the paired number-syllable material preceded that of the serial nonsense material. This is not the case for any other subject.) The curves for the paired meaning material, subjects G and H, show again as was indicated in our average tabulations, that there is little if any reduction in the number of repetitions for the practice given. The almost classical initial drop is found in most but not in all of these curves. It appears most prominently in the curves for subjects A, B, C, O, and L. In the curves for the meaning material, subjects G and H, there is no initial drop.

Bringing the facts presented in our tabulations and graphs together, we may conclude that in general improvement due to practice in the ability to memorize specific kinds of material is evinced by the results for nearly all our subjects. This is, as has been intimated before, in complete accord with common psychological doctrine. We may add that it is clear that the amount of improvement possible is dependent upon the kind or nature of the material practiced upon. The lack of improvement in the meaning material, for instance, for our subjects indicates that the more familiar material will give less practice effect. This simply amounts to saying, however, that this material has already in a sense been practiced upon and for this reason is familiar.

(2) The Effect of Practice upon the Form of the Learning Curves for Memory.

The purpose of the comparisons of the averages for the two halves of each individual subject's results, as well as, the averages of all the curves in each half of the practice periods for each kind of material, (Tables 10-13), is to get some idea of the effect by practice upon the percentages reproduced during each period of halves, thirds, and sixths; hence upon the curves or these particular points in the curves. In a comparative survey of the tables for the two halves of the results for each subject, it is clear that uniformity rather than difference is the outstanding characteristic. It will not do, however, to accept at once this uniformity as evidence of no general change in the curves, for the differences even though they may be small would be significant if they should be found to be running in the same direction at a certain point in the curve for all or most of the subjects. If, for instance, it should be found that all the subjects for a certain specific kind of material should show an increase in the percentage reproduced for the first third with a consequent decrease somewhere else after practice, then it would be fair to conclude that practice does have an influence upon this particular point in the curve.

A survey of the tabulations, however, shows at once that some subjects have an increase while others have a decrease at certain points in the averages for the last half of the practice periods. In order to bring the facts of increase and decrease into a more compact form, we constructed the tables of "Increase & Decrease" given in the tabulations. These tables show the number of subjects having an increase in the average and the number of subjects having a decrease in the average at the various points of the curve for each kind of material during the last half of the practice periods. The table for the paired nonsense material, for instance, shows that for most points about one half of the subjects show an increase and the other half a decrease in the last half of the practice periods. In the case of the serial nonsense material four of the five subjects show an increase in the last half for the second and third sixth of the presentations. However, the uniformity found in the table of averages for this material robs this fact of any significance that might be attributed to it. The tables of increase and decrease for the meaning and the number-syllable material are of little value except to show that for these few subjects there is no uniformity and that the variations are likely due to chance or individual differences.

The four tables of averages given in the tabulations were made from averages of all the curves for each kind of material. The number of curves from which the averages were made is given in the first column. The averages for the first half of the practice periods are marked I and those for the second half are marked II. It will be seen that the uniformity between the two halves is even more striking in these general averages for each kind of material.

In order to summarize, the following averages from the four tables of averages and the totals from the tables of increase and decrease are given. In Table 14, row I thus gives the averages for the first half and row II the averages for the second half of the practice periods or curves of seventeen subjects with a total of 261 curves. The table of increase, Table 15, shows the number of subjects whose averages were increased and the table of decrease the number of subjects whose averages were decreased for the second half of the practice periods.

TABLE 14

Averages of Averages

No of Curves		Halves 1	Halves 2	Thirds 1	Thirds 2	Thirds 3	Sixths 1	Sixths 2	Sixths 3	Sixths 4	Sixths 5	Sixths 6
I	130	66.5	33.5	46.5	35.3	18.2	25.7	20.8	20.0	15.3	8.9	9.3
II	131	67.7	32.3	48.2	34.2	17.6	26.4	21.7	19.6	14.7	9.3	8.3

TABLE 15

Increase and Decrease—Totals

	1	2	1	2	3	1	2	3	4	5	6
No. Increase	9	8	11	8	5	8	11	7	7	7	7
No. Decrease	8	9	6	9	12	9	6	10	10	10	10

The averages for the two halves of the practice periods shown in these general average tables present results which indicate a rather remarkable uniformity, the table of increase and decrease shows that about one half of the subjects have averages in the second half which are above those in the first half while for the other half of the subjects the opposite is true. Both of these results argue very much against any possible uniform change in the curve as a result of practice.

While these tabulations are fresh in mind, it may be well to call attention to another problem upon which these results will have a bearing. It will be remembered that there was in most cases a considerable reduction in the number of presentations required for learning a group of material after practice. The reduction was especially marked in case of the number-syllable material. Now it would be natural to infer that the memory curve which resulted from 15 or 20 repetitions might be very different in form from one that resulted from 5 or 10 repetitions. Now if we find that there is no change in the form of the curve due to practice while there is a change in the number of repetitions required then it would follow that the form of the curve is not effected by the number of repetitions required in learning. This, it will be remembered, seems to be the situation. The number-syllable material in which the number of presentations was reduced by almost one half in the second half of the practice did not show any more of a change in the form of the curve than the meaning material in which there was no reduction in the number of repetitions.

The facts, as shown in the tabulations of averages by halves above, are presented in greater detail in the graphs on Plates I, II, and III. These show the percentages reproduced at various sixths for each individual memory curve and for the whole period during which practice was continued.

Before taking up the question of practice effect upon the curves as shown in the graphs, permit us to digress from the main topic to point out some prominent features in the graphs. The marked periodic variations found in the results of some of the subjects are here brought into prominence. In the graph of subject B this is more evident than in those of other subjects. If, for instance, we compare the points in curve 12 or 13 of graph III with the points in curve 5 or 21, it is quite evident that these are quite different in form. The midpoint of curve 12 is near the 50 per cent line while those of curves 5 and 21 are near the 75 per cent line. It is clear that curve 12 comes nearer to being a straight line than any of the others. This indicates that in a group of memory curves great individual variations are to be expected. Another prominent phase of the graphs of this subject is the marked gradual drop in graphs II, III, IV, and V from period or curve 5 to 12; and the gradual rise again from period or curve 12 to 21. Some of the other graphs show gradual changes of a similar nature but these are not so prominent. For these variations we have no explanation to offer. They can hardly be due to changes in the methods of memorizing, for that would not likely give such a progressive and continuous change for such a large number of periods. Nor can they be attributed to practice since the change is first in one direction and afterwards in another. The marked parallelism throughout their course is quite evident in the graphs of most of the subjects. A careful survey of the plates indicates that in practically every one of them graphs I and V are much less variable and approach much nearer to a straight line than the intervening graphs II, III, and IV. This indicates that the memory curves tend to be more uniform at the beginning and near the end than at the midpoints. This, however, is to be expected since they must all begin at zero and end at one hundred.

Returning to our problem of practice effect upon the percentages reproduced at various sixths it will be best to consider the graphs of each subject separately. Due to the possibility of periodic variations in the graphs it is rather difficult to draw any definite conclusions. Some observations, however, upon this point will be in place even if we have to depend in the main upon the tabulation of averages for more definite conclusions.

For subject A, graph II is the only one which in any sense shows anything like a consistent change that might be attributed to the effect of practice; this being an apparent decline from the beginning to the end.

For subject B, Plate I, we find a rather interesting and variable group of graphs. Graphs III, IV, and V start far up and move down more or less parallel to one another; graph V to the ninth period, graph IV to the tenth, and graph III to the twelfth period. Graphs IV and V come up again to their original level while graph III seems to remain on a much lower level. If this graph is to correlate with graphs III of the other subjects it is not likely that it would ever come up again to its original high level.

For subject C, Plate I, graphs IV and V seem to indicate a slight decline from their original level. It will be noted, however, that this change is found principally from the thirteenth period on, so that if we take into consideration the possible periodic variations this feature looses much of what might be considered a practice effect.

For subject D, graphs I, II, and III appear to rise slightly from their original level. It is likely that graph I would maintain a higher level due to the fact that it starts on a comparatively low level.

For subject E, graphs II and III appear to tend towards a lower level. The same is true for graphs I and IV of subject N. For subjects O and M, there are no pronounced changes in any of the graphs. In general the graphs of subjects E, N, O, and M, (Plate II), are very regular and have only a very few slight variations.

For subject G, Plate III, nothing that can be called a permanent change in the graphs is found; while for subject H, graphs I, II, and III appear to rise from their original level.

For subject L, Plate III, all the graphs except graph I seem to rise from their early level; while for subject M, (serial nonsense material), graphs I and II appear to fall from their early level.

It may be observed that in most cases where there is any change in the graphs that might be interpreted as evidence of practice effect, this change is in no case very large. In the following table, (Table 16), we have brought all these possible changes together for comparison. The Roman numerals at the head of each row designates the graphs for which the following changes occur. The letter indicating the subject is found at the top of each column. A zero indicates no change, D a possible decline, and R a possible rise from the original level.

TABLE 16

	Paired Nonsense					Number-syllable			Meaning		Serial	
	A	B	C	D	E	N	O	M	G	H	L	M
I	O	O	D	R	O	D	O	O	O	R	O	D
II	D	D	D	R	D	O	O	O	O	R	R	D
III	O	D	D	R	D	O	O	O	O	R	R	O
IV	O	O	R	O	O	D	O	O	O	O	R	O
V	O	O	R	O	O	O	O	O	O	O	R	O

The table shows quite clearly that, even if we accept the possible or seeming changes in the graphs as evidence of practice effect, they appear in only some of the curves for some of the subjects and in no case does the same type of change occur uniformly for any one graph for all the subjects in the same material. If there is any practice effect, the most that can be said for it is that it is something that occurs for only some subjects and is of a particular kind for that subject alone. Even this position is questionable when we note the periodic variations that occur in the graphs.

Combining the facts brought out in the graphical representations and those from the tabulations of averages by halves, we are lead, it seems, to but one conclusion, and that is, that while individual curves may vary from time to time to a very large extent, anything that can be called a uniform permanent effect or change in the curve resulting from practice does not occur.

Concluding Statements

The survey of the results relative to practice effect upon the number of repetitions and the form of the memory curve have led us to the following conclusions:

1. The effect of practice upon any material of the same kind and the same length results in a reduction of the number of repetitions required to reproduce accurately equal amounts of that specific kind of material.

2. The amount of reduction in each case is dependent upon the kind or nature of the material and the subject concerned.

3. The form of the memory curve for any individual and for any kind of material may vary for any individual curve and slightly for longer periods but anything like a general change in the form of the curve does not occur as a result of practice.

4. A change in the number of repetitions required for memorizing does not have any influence upon the form of the memory curve.

Sec. 2. Individual Differences in Memory Curves.

Do the learning curves for memory differ in form for different individuals?

To answer this question it was necessary to adopt some method of comparing the curves of different subjects. Two difficulties presented themselves. In the first place, the curves were found to be so much alike that a graphical comparison would not bring out the differences, if there were any. In the second place, it was not easy to bring together a number of individual curves in such a way as to make comparison possible.

The first difficulty has been overcome in part by again resorting to the tabulation method. Specific points in the average curve of each subject were selected and the different individual curves were thus compared by comparing these specific points.

In the following tables, (Tables 17-24), these specific points for each subject are tabulated so as to make it possible to compare them with those of other subjects who memorized the same material. In the first table, (Table 17), will be found the tabulations from the subjects who memorized the paired nonsense material of 12 pairs each. In the first column, marked Sub., is found the letter of the alphabet designating the subject; in the second column, marked C, the number of individual curves for the subject from which his average curve was determined; in the third column, marked P, the average number of repetitions required by the subject in order to reproduce accurately the twelve syllables. Following these in the columns marked halves, thirds, and sixths will be found the average percentages reproduced by each subject in halves, thirds, and sixths of the time or effort expended. In the same way the various points for the subjects using the other kinds of materials are tabulated.

Tabulations of Averages for Individual Subjects in halves, thirds, and sixths for the Study of Individual Differences. Tables 17 to 24.

TABLE 17

Paired Nonsense Material, (12 Pairs).

			Halves		Thirds			Sixths					
Sub.	C	P	1	2	1	2	3	1	2	3	4	5	6
A	26	7.1	64.7	35.3	45.8	34.4	19.8	21.2	24.6	18.9	15.5	8.8	11.0
B	26	6.5	67.9	32.1	43.5	36.5	20.0	18.9	24.6	24.4	12.1	8.5	11.5
I	6	4.3	66.3	33.7	45.6	35.3	19.1	22.3	23.3	20.7	14.6	9.9	9.2
E	12	4.8	58.5	41.5	34.7	41.5	23.8	15.2	19.5	23.8	17.7	15.6	8.2
D	16	9.0	55.8	44.2	33.5	42.3	24.2	13.8	19.7	22.3	20.0	12.3	11.9
C	20	8.4	55.3	44.7	35.4	40.8	23.8	17.2	18.2	19.9	20.9	13.6	10.2
F	6	4.8	54.4	45.6	34.4	39.9	25.7	13.4	21.0	20.0	19.9	11.9	13.8
G	6	4.7	57.9	42.1	36.1	42.1	21.8	13.9	22.2	21.8	20.3	13.8	8.0
H	6	3.5	60.2	39.8	31.5	46.6	21.9	5.7	25.8	28.7	17.9	12.8	9.1

TABLE 18

Serial Nonsense Material, (12 Syllables).

			Halves		Thirds			Sixths					
Sub.	C	P	1	2	1	2	3	1	2	3	4	5	6
R	12	8.6	70.2	29.8	57.6	23.9	18.5	42.2	15.4	12.6	11.3	8.9	9.6
K	6	2.5	67.4	32.6	43.6	36.6	19.8	21.6	22.0	23.8	12.8	9.9	9.9
J	6	5.0	74.1	25.9	64.3	16.2	19.5	41.7	22.6	9.8	6.4	10.8	8.7
M	24	5.1	73.6	26.4	54.2	30.8	15.0	30.5	23.8	19.3	11.5	8.1	6.8
N	6	4.2	77.2	22.8	62.8	23.5	13.7	37.0	25.8	14.4	9.1	7.0	6.7
Q	9	6.1	71.0	29.0	53.9	30.2	15.9	33.1	20.8	17.1	13.1	8.2	7.7
P	10	5.3	69.7	30.3	55.5	29.2	15.3	32.8	22.7	14.2	15.0	8.2	7.1
O	6	5.2	69.9	30.1	58.9	22.9	18.2	36.7	22.2	11.0	11.9	11.3	6.9
S	6	4.7	68.6	31.4	53.6	28.3	18.1	31.7	21.9	15.0	13.3	9.3	8.8
L	24	7.0	76.6	23.4	56.2	31.2	12.6	34.6	21.6	20.4	10.8	6.6	6.0

TABLE 19

Paired Numbers and Syllables, (9 Pairs).

			Halves		Thirds			Sixths					
Sub.	C	P	1	2	1	2	3	1	2	3	4	5	6
M	8	11.0	70.4	29.6	49.4	35.4	15.2	31.2	18.2	21.0	14.4	6.3	8.9
N	8	10.0	56.1	43.9	40.5	34.2	25.3	25.9	14.6	15.6	18.6	13.1	12.2
T	6	5.7	58.6	41.4	29.3	36.9	23.8	22.6	16.7	19.3	17.6	9.5	14.3
O	8	13.0	59.0	41.0	38.4	39.7	21.9	22.7	15.7	20.6	19.1	10.5	11.4

TABLE 20

Paired Numbers and Syllables, (12 Pairs).

			Halves		Thirds			Sixths					
Sub.	C	P	1	2	1	2	3	1	2	3	4	5	6
M	6	8.2	67.3	32.7	44.6	32.8	22.6	27.2	17.4	22.7	10.1	14.6	8.0
N	6	8.2	65.4	34.6	50.1	26.4	23.5	31.8	18.3	15.3	11.1	15.0	10.5
Q	6	9.7	64.4	45.6	42.3	32.8	24.9	21.7	20.6	22.1	10.7	14.5	10.4
T	6	4.8	53.6	46.4	31.5	41.2	27.3	11.7	19.8	22.1	19.1	15.3	12.0
P	6	9.8	66.1	33.9	48.3	30.3	21.4	28.5	19.8	17.8	12.5	16.3	5.1

TABLE 21

Paired Meaning Material, (18 Pairs).

			Halves		Thirds			Sixths					
Sub.	C	P	1	2	1	2	3	1	2	3	4	5	6
D	6	6.7	64.3	35.7	39.0	40.2	20.8	14.7	24.3	25.3	14.9	7.7	13.1
I	10	2.9	80.2	19.8	59.4	29.6	11.0	30.5	28.9	20.8	8.8	5.7	5.3
G	20	3.2	66.7	33.3	46.6	37.6	15.8	22.8	23.8	20.1	17.5	8.6	7.2
H	20	4.2	75.0	25.0	53.3	33.9	12.8	27.3	26.0	21.7	12.2	7.3	5.5

Sub. = Subject; C = curves; P = Number of presentations.

TABLE 22

Paired Nonsense Material, (18 Pairs).

			Halves		Thirds			Sixths					
Sub.	C	P	1	2	1	2	3	1	2	3	4	5	6
B	3	5.2	69.2	30.8	49.5	34.9	15.6	29.0	20.5	19.7	15.2	6.8	8.8
D	5	9.6	59.3	40.7	41.7	33.3	25.0	12.0	29.7	17.6	15.7	17.2	7.8
C	4	8.0	54.2	45.8	35.2	44.8	20.0	17.4	17.8	19.0	25.8	9.5	10.5

TABLE 23

Paired Nonsense Material, (36 Pairs).

Sub.	C	P	1	2	1	2	3	1	2	3	4	5	6
E	3	7.0	76.2	23.8	54.9	33.8	11.3	23.2	31.7	21.3	12.5	6.7	4.6
D	6	10.5	61.5	38.5	38.7	40.7	20.6	12.9	25.8	22.8	17.9	13.6	7.0

TABLE 24

Serial Nonsense Material, (18 Pairs).

			Halves		Thirds			Sixths					
Sub.	C	P	1	2	1	2	3	1	2	3	4	5	6
N	6	4.5	72.3	27.7	54.1	28.9	17.0	30.8	23.3	18.2	10.7	7.8	9.2
Q	6	7.7	78.8	21.2	59.6	32.7	7.7	30.5	29.1	19.2	13.5	4.2	3.5
P	6	6.2	78.3	21.7	58.8	30.7	10.5	38.6	20.2	19.5	11.2	6.2	4.3

Sub. = subject; C = curves; P = Number of presentations.

Individual Differences Indicated by the Tables.

A. Number of Repetitions: A glance over the columns marked P makes it clear that there is considerable difference in the number of repetitions required by different subjects in order to reproduce the same material. Some of the subjects require as much as three times the number of repetitions required by others. This fact is in accord with common observations and may be due to individual differences in general or to method or to both.

B. Individual Differences in the Percentages Reproduced at Various Intervals During the Learning, Hence in the Form of the Memory Curves.

Turning our attention to this, our main problem, a conclusion is not so easily reached. Certain types of uniformity are evident at first sight (Tables 17-24). The columns, indicating the percentages reproduced by halves, show that every one of the subjects compared reproduced from ten to forty percent more during the first half than during the second half of the effort expended. It is evident, therefore, that there is for all these subjects a flattening of the curve in its upper half. In this sense, at least, there is uniformity. Turning to the columns showing the percentages reproduced by thirds, we find again that every one of the subjects agree in that the smallest percentage is reproduced during the last third. The same uniformity does not hold, however for the first and second third. Here variations are found not only for different materials but for different subjects as well.

Turning to the table for the paired nonsense material, (Table 17), we find that three subjects, A, B, and I, uniformly reproduced almost ten per cent more during the first than during the last third. The other six subjects, on the other hand, reproduced from five to fifteen per cent more during the second than they did during the first third. It is evident that the steepest part of the curves for the six subjects is in the middle third while that for the three subjects A, B, and I is in the first third. Turning to the reproductions by sixths, we get the variations somewhat more in detail. Subjects A, B, and I are again marked off from the others by the larger percentages reproduced in the first and second sixth and the much smaller percentages reproduced in the fifth sixth. It looks somewhat as if we had two types of learners here, one group reproducing the most during the first third of their effort and the other reproducing the most during the middle third. Besides the differences noted above for the two groups, subject H stands alone in the very low percentage reproduced in the first sixth of his time or effort. These are the principal variations found in this table, but other minor differences for each individual will, upon a careful study, reveal themselves.

In the serial nonsense material, (Table 18), no such differences, as noted above, can be found. In the case of thirds, all subjects agree in that the largest percentage is reproduced in the first third. In all cases except one, over fifty percent is reproduced in this third. In the case of the sixths, all these subjects except one agree in that the largest percentage is reproduced in the first sixth and the second largest in the second sixth. A rather marked uniformity is found in the fifth and last sixths, while some variation is found in the third and fourth sixths. On the whole, it seems that the subjects in this material are very uniform in the form of their curves as shown by the tabulations.

In the paired number-syllable material, (Tables 19 and 20), both the 9 and the 12 pairs, the variations are somewhat more prominent. Even here, however, considerable uniformity is found. The tabulations show that for most of the subjects in these materials the largest percentage is reproduced in the first third while in all cases the smallest percentage is reproduced in the last third. In the 9 pair material, all the subjects reproduced the largest percentage in the first sixth but this is in most cases only slightly above that reproduced in some of the other sixths. In the 12 pair material, a rather uniformly large percentage is reproduced by all the subjects in the fifth sixth, while in the other sixths minor variations are found.

The number of subjects are rather limited for the other kinds of material. The number of curves from which each subjects average is made up are also few in number. We leave these tables, (Tables 21, 22, 23, and 24), to speak for themselves. In general they indicate considerable variation for different subjects, while at the same time much uniformity is evident.

Certain general features in the tabulations for each kind of material bring out some uniformities which must not be overlooked. These have more bearing on the question of variation in the form of the curves due to differences in material, but will be referred to here in as much as they also have a bearing on the question of individual differences.

The following diagrams, (Table 25), have been constructed to bring out some of these features. The Roman numerals over each column indicate the respective sixths in the curve. The

TABLE 25

Paired Nonsense Material, 12 Pairs.

	II	III	IV	I	V	VI
1	5	3	1			
2	2	4	1	2		
3	2	2	4	1		
4			3	4	2	
5				1	4	4
6				1	3	5
Av.	22.1	22.3	17.7	15.5	11.9	10.3

Serial Nonsense Material.

	I	II	III	IV	V	VI
1	9		1			
2		10				
3	1		6	2	1	
4			2	7	1	
5			1		7	2
6				1	1	8
Av.	34.3	21.9	15.7	11.5	8.8	7.8

Syllables and Numbers (9 pairs)

	I	III	IV	II	VI	V
1	4					
2		3	1			
3		1	2	1		
4			1	3		
5					3	1
6					1	3
Av.	25.6	19.1	17.4	16.3	11.7	9.9

Syllables and Numbers (12 pairs)

	I	III	II	V	IV	VI
1	3	2				
2	1	1	3			
3		2	2		1	
4				5		
5					4	1
6	1					4
Av.	24.2	20.0	19.2	14.7	12.7	9.2

Paired Meaning Material, 18 pairs

	I	II	III	IV	V	VI
1	2	1	1			
2	1	3				
3			3	1		
4	1			3		
5					3	1
6					1	3
Av.	23.8	25.7	22.0	13.4	7.3	7.8

Arabic numerals in the vertical column at the head of each row designate the position of each sixth as to the percentage learned. To illustrate: In the diagram for the paired material, the figure 5 under Roman II and after Arabic 1 shows that five subjects reproduced the largest percentage in the second sixth. Likewise the figure 1 after Arabic 6 and under Roman I shows that one subject reproduced the smallest percentage in this sixth. In the last line in each of these diagrams will be found the average percentages reproduced by these subjects for each sixth of the time or effort used.

These diagrams show quite clearly that we have considerable uniformity in the general aspects of the curves for all subjects in each kind of material. They also show that the averages for all the subjects in each kind of material are a good indication of the trend of the curve for most of the subjects. It is also clear that some subjects vary slightly from this average trend and the number of these are indicated in part by the diagrams. To illustrate:

The diagram for the serial nonsense material shows that for most of the subjects there is a gradual reduction in the percentages reproduced from the first to the last sixth. This is quite clearly shown by the fact that the largest numbers are found on the diagonal. At the same time, a few subjects vary from this order. One subject, for instance, reproduced the largest percentage in the third sixth while all the others reproduced the largest percentage in the first sixth. This means that for one subject the steepest part of the curve is not at the beginning but in the third sixth of the curve. The diagonals on the diagrams, where in most cases the largest numbers are found, show the trend of the curves while the numbers on the sides of the diagonal indicate the number of variations. It will be seen that in two out of five kinds of materials, we have been able to retain the regular order of the sixths from the first to the last.

It appears that the uniformity among these subjects is the outstanding fact, when we disregard differences for different materials. This, however, does not permit us to disregard the differences. It may be well in this connection to recall the comparisons made in our discussion of practice effect. Few such marked differences, as we have found here for different subjects, were found between averages of the first and the last half of each subject's curves. If the order, from the greatest to the least per cent reproduced, was from the first to the last sixth in the averages for the first half, this order was in most cases retained in the averages for the last half. On the other hand, we must not stress differences of this type too far. It is well to remember that an interchange of position in this respect may easily take place where the difference between two sixths in all cases is very small. This is quite common in the results from some of the materials used. It is, in fact, little less than remarkable that so many subjects should show such uniformity, as is indicated by the diagrams, when we keep this fact in mind. The close clustering of the subjects around the diagonal, where they are not on the diagonal, in the diagram, is very good evidence of uniformity. The further fact that marked differences occur in the curves for different materials, (See later discussion), while the results for subjects within a particular material are quite uniform, indicates that individual subjects' differences are after all not so pronounced.

Concluding Statements

1. Individual subjects differ very much in the number of repetitions required in order to reproduce accurately the same material. This difference for some of our subjects is as large as three to one.

2. All subjects reproduced more during the first half of the time or effort expended than during the last half.

3. All subjects reproduced least during the last third of the time. While some subjects reproduced most during the first third others reproduced the largest amount during the middle third.

4. In case of sixths in time or effort, certain minor variations occur but most of the subjects agree in that they reproduced in order from the largest to the smallest percent at almost the same intervals or sixths; the order of the intervals depending upon the kind of material learned.

5. The curves for individual subjects appear to differ very much more for the first sixth than for any other interval of the curve, while the least variation appears to be in the fifth and the second sixths of the curve.

6. In general, we may say that some differences do occur in the curves for individual subjects, but certain uniformities or tendencies are certainly the more prominent facts. These general tendencies appear to differ with the kind of material learned. Of this, more will be said in a later discussion.

Sec. 3. Modifications in the Form of the Memory Curves Due to Variations in the Kind or Nature of the Material.

Sec. 3. Modifications in the Form of the Memory Curves Due to Variations in the Kind or Nature of the Material.

The problem here was to determine whether the form of the curve would change with a change in the material to be learned. The reader has already, in connection with our former discussion, noted some aspects of this question as it appeared in the tabulations for individual differences.

For the comparison of results from different materials, the diagrams given on a former page, (Table 25), are reproduced as they were except that the various sixths are given in the order from first to last. In each of these diagrams, (See Table 26), are found the averages for each sixth of these curves of the subjects for each kind of material.

Since, as has been observed in our former discussion, certain minor differences for individual subjects are found, the results of individual subjects from whom we obtained curves for more than one kind of material have been tabulated for comparative purposes. (See Table 27.) These, together with the individual differences indicated by the diagrams, thus serve as a check upon the averages given. The averages for each kind of material are graphically represented in halves, thirds, and sixths on the plate following the diagrams. (See Plate IV.)

The different materials from which we obtained data for this study are as follows: the paired nonsense, the serial nonsense, the number-syllable, and the meaning material. Beside these, data were obtained from one subject learning consonant syllables paired with nonsense syllables, and from one subject learning the serial consonant syllables of three consonants each.

In all except one case, only one length of each kind of material has been included in this study. The exception is that of the number-syllable material, for which we have included both the 9 and the 12 paired material. Certain uniformities found in each of these help to set off the number-syllable material from the others. The length of material selected in each case was that for which we had the largest amount of data. In the case of the meaning material, this was the paired 18; while in case of all the others it was the 12 paired and the 12 serial material.

In the presentation of the facts bearing upon this question, we are, as noted above, also making use of averages from groups of individual subjects. (Table 27.) The advisability of this procedure might be questioned on the basis of differences found for individual subjects. It should be remembered, however, that the differences, where found, were rather small and that most of the subjects conformed in the general features of the curves for each kind of material. The validity of the averages, as an indication of the form of the curves, depends upon the degree of uniformity with which different subjects conform to them, as well as the number of subjects concerned.

Our problem here, it will be remembered, is not to determine the absolute form of the curve for each kind of material learned but rather to determine whether there is any evidence of differences in the form of the curves. Our data are not sufficient to establish absolutely the definite form of the curve for each kind of material for an unlimited number of subjects; yet certain uniformities in the curves of subjects using the same kind of material make it possible to point out certain general features of the curves for each.

TABLE 26

Paired Nonsense Material (12 pairs)

	I	II	III	IV	V	VI
1		5	3	1		
2	2	2	4	1		
3	1	2	2	4		
4	4			3	2	
5	1				4	4
6	1				3	5
Av.	15.7	22.1	22.3	17.7	11.9	10.3

Serial Nonsense (12 syllables)

	I	II	III	IV	V	VI
1	9		1			
2		10				
3	1		6	2	1	
4			2	7	1	
5			1		7	2
6				1	1	8
Av.	34.3	21.9	15.7	11.5	8.8	7.8

Number-syllable (9 pairs)

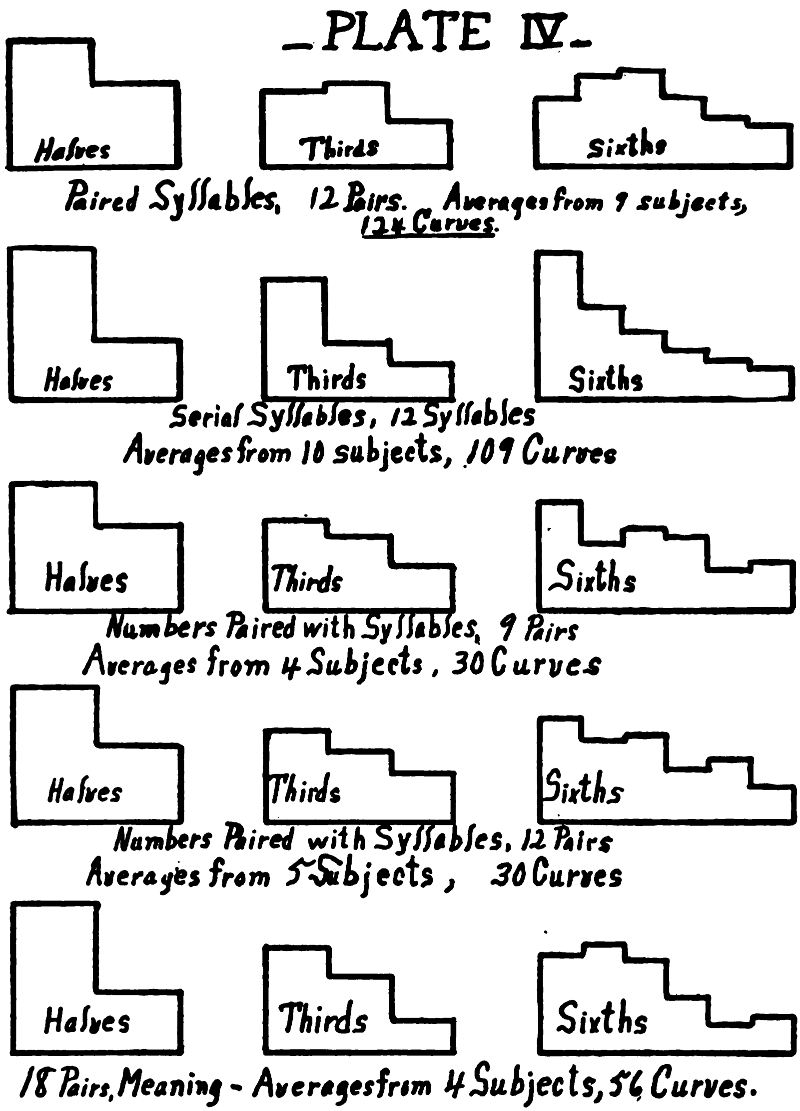
	I	II	III	IV	V	VI
1	4					
2			3	1		
3		1	1	2		
4		3		1		
5					1	3
6					3	1
Av.	25.6	16.3	19.1	17.4	9.9	11.7

Number-syllable (12 pairs)

	I	II	III	IV	V	VI
1	3		2			
2	1	3	1			
3		2	2	1		
4					5	
5				4		1
6	1					4
Av.	24.2	19.2	20.0	12.7	14.7	9.2

Paired Meaning (18 pairs)

	I	II	III	IV	V	VI
1	2	1	1			
2	1	3				
3			3	1		
4	1			3		
5					3	1
6					1	3
Av.	23.8	25.7	22.0	13.4	7.3	7.8



The graphs above show the relative percentages reproduced in halves, thirds, and sixths of the time or effort expended.

TABLE 27

Tabulations from Curves of Individual Subjects to Study Variations Resulting from Different Kinds of Material.

S12 = Results from the 12 Serial nonsense syllables.
N9 = " " " Number-syllable material of 9 pairs.
N12 = " " " " " " " 12 pairs.
M18 = " " " Meaning material of 18 pairs.
PN = " " " Paired nonsense material of 12 pairs.
PC = " " " Paired consonant-syllable material of 12 pairs.
SC = " " " Serial consonant syllables of 12 syllables.
C = the number of curves from which the results are an average.
P = the average number of presentations required for learning.

			Halves		Thirds			Sixths					
	C	P	1	2	1	2	3	1	2	3	4	5	6
Subject M													
S12	24	5.1	73.6	26.4	54.2	30.8	15.0	30.5	23.8	19.3	11.5	8.1	6.8
N9	8	11.0	70.4	29.6	49.4	35.4	15.2	31.2	18.2	21.0	14.4	6.3	8.9
N12	6	8.2	67.3	32.7	44.6	32.8	22.6	27.2	17.4	22.7	10.1	14.6	8.0
Subject Q													
S12	9	6.1	71.0	29.0	53.9	30.2	15.9	33.1	20.8	17.1	13.1	8.2	7.7
N12	6	9.7	64.4	45.6	42.3	32.8	24.9	21.7	20.6	22.1	10.7	14.5	10.4
Subject N													
S12	6	4.2	77.2	22.8	62.8	23.5	15.7	37.0	25.8	14.4	9.1	7.0	6.7
N9	8	10.0	56.1	43.9	40.5	34.2	25.3	25.9	14.6	15.6	18.6	13.1	12.2
N12	6	8.2	65.4	34.6	50.1	26.4	23.5	31.8	18.3	15.3	11.1	13.0	10.5
Subject O													
S12	6	5.2	69.9	30.1	58.9	22.9	18.2	36.7	22.2	11.0	11.9	11.3	6.9
N9	8	13.0	59.0	41.0	38.4	39.7	21.9	22.7	15.7	20.6	19.1	10.5	11.4
Subject T													
N9	6	5.7	58.6	41.4	39.3	36.9	23.8	22.6	16.7	19.3	17.6	9.5	14.3
N12	6	4.8	53.6	46.4	31.5	41.2	27.3	11.7	19.8	22.1	19.1	15.3	12.0
Subject P													
S12	10	5.3	69.7	30.3	55.5	29.2	15.3	32.8	22.7	14.2	15.0	8.2	7.1
N12	6	9.8	66.1	33.9	48.3	30.3	21.4	28.5	19.8	17.8	12.5	16.3	5.1
PC	6	10.5	58.1	41.9	35.0	33.2	31.8	18.6	16.4	23.1	10.1	16.4	15.4
Subject U													
S12	3	2.7	74.2	25.8	56.4	30.8	12.8	28.2	28.2	17.8	13.0	6.5	6.3
SC	6	5.5	54.4	45.6	49.2	27.9	22.9	32.0	17.2	5.2	22.7	13.5	9.4
Subject I													
PN	6	4.3	66.3	33.7	45.6	35.3	19.1	22.3	23.3	20.7	14.6	9.9	9.2
M18	10	2.9	80.2	19.8	59.4	29.6	11.0	30.5	28.9	20.8	8.8	5.7	5.3
Subject H													
PN	6	9.8	60.2	39.8	31.5	46.6	21.9	5.7	25.8	28.7	17.9	12.8	9.1
M18	20	4.0	75.0	25.0	53.3	33.9	12.8	27.3	26.0	21.7	12.2	7.3	5.5
Subject D													
PN	6	9.0	55.8	44.2	33.5	42.3	24.2	13.8	19.7	22.3	20.0	12.3	11.9
M18	6	6.7	64.3	35.7	39.0	40.2	20.8	14.7	24.3	25.3	14.9	7.7	13.1
Subject G													
PN	6	4.7	57.9	42.1	36.1	42.1	21.8	13.9	22.2	21.8	20.3	13.8	8.0
M18	20	3.2	66.7	33.3	46.6	37.6	15.8	22.8	23.8	20.1	17.5	8.6	7.2

Comparing the curves of these materials by the average percentages reproduced by halves, (See graphs Plate IV), it appears that by far the larger percentage is reproduced during the first half for each kind of material. In the actual percentages reproduced, however, they may be divided into two groups; including in the first the serial and the meaning material with averages of 71.9 per cent and 7.15 per cent respectively in the first half, and in the second group the paired number-syllable, both the 9 and the 12 pairs, and the paired nonsense material with averages of 61.0 per cent, 63.4 per cent, and 60.1 per cent respectively for the first half of the time or effort expended.

Comparing the curves of the materials as reproduced on the average by thirds, we may again make the same grouping of the serial and the meaning material. There is here, however, less uniformity between the two although the percentages reproduced from the greatest to the least is from the first to the last third in order. In the second group, the number syllable material show percentages decreasing from the first to the last third; while the paired nonsense material is unique in that the largest percentage is reproduced in the middle third.

Comparing the curves of the materials in greater detail by sixths, we find more variations.

In case of the paired nonsense material the averages, as shown on the graphs, (Plate IV), indicate that the largest percentage is reproduced during the third sixth, but this is only .2 per cent above that of the second sixth. The tabulations for individual subjects, (Table 27), show that this, almost equal percentages for these two sixths, is equally characteristic of the curves for the individual subjects. The same fact is shown in the diagram for this material, (Table 26). The more important fact here, however, is the comparatively small percentage reproduced during the first sixth. Judged either by the average percentages or by the number of subjects for whom it occurs, this sixth comes after the fourth in order from largest to smallest percentage reproduced. (See diagram, Table 26.) Thus it would appear that in this material we have a case where the "initial rise" does not occur. This is true not only for the average but for the curve of each individual subject who memorized this material. (See Table 27.) The same is true for the curves from this material in greater lengths, i.e., 18, 24, and 36 pairs, as we shall see later. (See Tables 28 and 29, paired nonsense material.)

The graph for the serial nonsense material indicates a somewhat different type of curve. Here the first sixth shows by far the largest percentage of reproduction. This is equally true of curves for individual subjects save one. (See diagram, Table 26.) The same we find to be true for the same material of greater lengths, i.e., 18 syllables. (See Table 28.) The large numbers found on the diagonal, (Table 25), and the close clustering around it of the rest of the numbers representing the number of subjects,—shows further the uniformity for the subjects in the gradual decrease in the percentages of this material reproduced from the first to the last sixth.

The Meaning Material: We have found already by the comparisons of halves and thirds that this material gives a curve most like that for the serial material just discussed. In comparisons by sixths, however the similarity is not nearly so striking. Especially is this fact true for the first sixth in which there is a much lower percentage of reproduction than in that for the serial material. For the meaning the average percent reproduced for the second sixth is nearly 2 per cent higher than that for the first. That this is the prevailing tendency may well be questioned when we take into consideration the curves for individual subjects. In fact it would appear that the first rather than the second sixth gives the largest percentage for most subjects. This is supported as we shall see later by the fact that the same material of 12 pairs results in a curve in which the largest percentage is reproduced in the first sixth. Our data are rather limited but there is, it appears, a gradual decrease in the percentages reproduced from the first sixth to the last which indicates that the curve for this material in this respect is like that of the serial nonsense material. This seems to be true whether measured by the averages or by the curves for individual subjects. The principal difference between the curves for the paired meaning and the serial nonsense material thus seems to be that the former shows a smaller percentage of reproduction in the first sixth than does the latter.

The Number-Syllable Material: Taking the 9 and the 12 pair materials separately, the data are rather limited as to the number of subjects. Taking these together, however, certain uniformities set them off very clearly from the results of the other kinds of material. It may be said, first of all, that this material gives in every case, average and individual, a curve more nearly approaching a straight line than that of any other with which we have compared it. Still it has a large number of lesser variations which makes the curve more irregular than those for other materials. (See graphs on Plate IV). The averages in both the 9 and the 12 pair materials show that the largest percentage is reproduced in the first sixth and that a larger percentage is reproduced in the third than in the second sixth. Seven out of nine subjects reproduced a larger percentage during the third than during the second sixth. (See Tables 19, 20, and 27.) Thus both the averages and the results for the individual subjects indicate that this fact is characteristic for the curves for this material. At any rate, it is too uniform not to indicate that at this point these curves are different from those of other materials. There are differences between these two materials themselves, but when compared with the uniformities which they present as against the curves for the other materials these differences rather tend to emphasize the points in which they differ from other materials.

The Consonant Materials: From the paired consonant syllable material, we have the average curve for only one subject. It may be interesting to note that this resembles the curve for the paired number-syllable material in that a larger percentage is reproduced in the third than in the second sixth. (See Table 27, Subject P). For the serial consonant syllables, we likewise have the results from six curves of but one subject. This curve is not like that of the serial nonsense but rather like that of the paired number-syllable material.

Concluding Statements

1. For all the materials represented in our experiment, it appears that, although the actual percentages for the different ma-

terials vary, yet the largest percentage is reproduced during the first half of the time or effort expended.

2. Taking the percentages reproduced by thirds, it appears that for all the materials, except the paired nonsense, our subjects reproduced percentages from largest to smallest in order from the first to the last third.

3. In case of the paired nonsense material, our subjects on the average reproduced the largest percentage in the middle third, the initial first third being relegated to second place.

4. Taken by sixths, the order of reproduction from largest to smallest percentages was as follows: Paired Nonsense III or II, IV, I, V, and VI; Serial Nonsense I, II, III, IV, V, and VI; Paired Meaning I or II, III, IV, V, and VI; 12 Paired Number-syllable I, III, II, V, IV, and VI; and the 9 Paired Number-syllable I, III, II or IV, and V or VI.

5. In general the curve for the paired nonsense material is characterized by the *lack of the "rapid initial rise," its steepest parts being in the third and second sixths* after which there is a gradual decrease in the percentages reproduced; the curve for the serial nonsense material differs more from the paired than does that of any other and is characterized by a rapid initial rise after which there is a gradual decrease in the percentages reproduced to the last sixths; the curve for the meaning material is much like that for the serial nonsense, however, the initial rise is spread over the first half of the curve; the curve for the number-syllable material is characterized by the fact that it more nearly approaches a straight line than any of the others, and it is like that for the paired nonsense material in that an almost equal percentage is reproduced in the second as in the third sixth.

Sec. 4. Effect upon the Form of the Memory Curve due to Changes in the Length of the Material.

The problem here was to determine whether a change in the length of the material would produce a change in the form of the curve. By length of material, we here mean the number of syllables or the number of pairs of associates to be learned by the subject. The lengths used were, nine, twelve, eighteen, twenty-four, and thirty-six. These lengths were tried out for four different kinds of material. (See Table 28 and 29.)

In order to compare the curves for various lengths of material, we have as in the former studies, tabulated the percentages reproduced in halves, thirds, and sixths of the time or effort expended. As in the study for the kinds of materials, we have made use of averages as well as results from individual subjects in the tabulations.

In table 28, we have the averages for all the subjects from whom we obtained curves for different kinds and lengths of material. The different lengths are grouped by materials from which the results were produced, since the curve varies for different materials. The length of the material is designated in each case in the table. In the column marked Subs., will be found the number indicating the number of subjects from whom the curves were obtained; in the column marked C, the total number of curves from which the averages were taken; and in the column marked P, the average number of repetitions required for complete reproduction in each case. The remaining columns give the average percentages reproduced in halves, thirds, and sixths of the time or effort expended.

In table 29, we have the same kind of tabulations as those in table 28, but here the figures are averages for individual subjects from whom curves were obtained for materials of more than one length. The explanations of abbreviations used, given at the head of this table, will make clear its contents.

A. Number of Repetitions: Before taking up a consideration of the form of the curves, a word must be said about the number of repetitions required for the different lengths of material.

The tabulations for the number-syllable material (Table 28), present the rather unusual fact that more repetitions were required for the shorter than for the longer materials. This is, however, the fact, and it is explained by the circumstances that the longer series in every case followed the learning of either the shorter number-syllable material or else some other material, while the shorter material always represents the first work of the subject. The effect of practice thus accounts for this anomalous

TABLE 28

Tabulations of Averages for Materials of Various Lengths.

Paired Number-syllable Material

			Halves		Thirds			Sixths					
Subs.	C	P	1	2	1	2	3	1	2	3	4	5	6
Nine Pairs													
5	36	9.2	58.4	41.6	40.9	36.6	22.5	25.5	15.4	17.5	19.1	10.1	12.4
Twelve Pairs													
5	30	8.1	63.4	36.6	43.4	32.7	23.9	24.2	19.2	20.0	12.7	14.7	19.2

Serial Nonsense Material

			Halves		Thirds			Sixths					
Subs.	C	P	1	2	1	2	3	1	2	3	4	5	6
Twelve syllables													
10	91	5.4	72.0	28.0	56.2	27.2	16.6	34.5	21.7	15.8	11.4	8.6	8.0
Eighteen syllables													
3	18	6.1	76.4	23.6	57.5	30.7	11.8	33.3	24.2	18.9	11.8	6.1	5.7

Paired Nonsense Material

			Halves		Thirds			Sixths					
Subs.	C	P	1	2	1	2	3	1	2	3	4	5	6
Twelve Pairs													
9	124	5.9	60.1	39.9	37.8	40.0	22.2	15.7	22.1	22.3	17.7	11.9	10.3
Eighteen Pairs													
3	12	7.6	60.9	39.1	42.2	37.6	20.2	19.5	22.7	18.7	18.9	11.2	9.0
Twenty-four Pairs													
1	6	7.7	66.1	33.9	42.8	38.9	18.3	15.4	27.4	23.3	15.6	12.0	6.3
Thirty-six Pairs													
2	9	8.7	68.9	31.1	46.8	37.3	15.9	18.0	28.8	22.1	15.2	10.1	5.8

Meaning Material

			Halves		Thirds			Sixths					
Subs.	C	P	1	2	1	2	3	1	2	3	4	5	6
Twelve Pairs													
2	8	4.3	64.4	35.6	44.6	34.7	20.7	25.0	19.6	19.8	14.9	14.1	6.6
Eighteen Pairs													
4	56	4.2	71.5	28.5	49.5	35.4	15.1	23.8	25.7	22.0	13.4	7.3	7.8

result. The effect of practice is also responsible in some of the other cases for the insignificant increase in the number of presentations with the lengthening of the material. Yet some of the cases can not thus be explained and they indicate that the number of repetitions required is in no way proportional to the length of the material. To get at the actual facts in this matter, it is necessary to turn to the results for individual subjects. Subject D (Table 29), learned the 18 pairs before the 12 pair series, so that the effect of practice would favor the shorter series. Yet the difference in the number of repetitions for the two lengths

TABLE 29

Tabulations from Curves of Individual Subjects for Materials of Various Lengths

N9 = Results from the paired number-syllable material, 9 pairs.
N12 = " " " " " " " 12 pairs.
S12 = " " " Serial nonsense syllables, 12 syllables.
P12 = " " " paired nonsense material, 12 pairs.
P18 = " " " " " " 18 pairs.
P24 = " " " " " " 24 pairs.
P36 = " " " " " " 36 pairs.
M12 = " " " " meaning material, 12 pairs.
M18 = " " " " " " 18 pairs.
S18 = " " " Serial nonsense syllables, 18 syllables.
C = the number of curves from which the averages were taken.
P = the average number of presentations required.

			Halves		Thirds			Sixths					
	C	P	1	2	1	2	3	1	2	3	4	5	6
Subject N													
N9	8	10.0	56.1	43.9	40.5	34.2	25.3	25.9	14.6	15.6	18.6	13.1	12.2
N12	6	8.2	65.4	34.6	50.1	26.4	23.5	31.8	18.3	15.3	11.1	13.0	10.5
Subject M													
N9	8	11.0	70.4	29.6	49.4	35.4	15.2	31.2	18.2	21.0	14.4	6.3	8.9
N12	6	8.2	67.3	32.7	44.6	32.8	22.6	27.2	17.4	22.7	10.1	14.6	8.0
Subject T													
N9	6	5.7	58.6	41.4	39.3	36.9	23.8	22.6	16.7	19.3	17.6	9.5	14.3
N12	6	4.8	53.6	46.4	31.5	41.2	27.3	11.7	19.8	22.1	19.1	15.3	12.0
Subject N													
S12	6	4.2	77.2	22.8	62.8	23.5	13.7	37.0	25.8	14.4	9.1	7.0	6.7
S18	6	4.5	72.3	27.7	54.1	28.9	17.0	30.8	23.3	18.2	10.7	7.8	9.2
Subject Q													
S12	9	6.1	71.0	29.0	53.9	30.2	15.9	33.1	20.8	17.1	13.1	8.2	7.7
S18	6	7.7	78.8	21.2	59.6	32.7	7.7	30.5	29.1	19.2	13.5	4.2	3.5
Subject P													
S12	10	5.3	69.7	30.3	55.5	29.2	15.3	32.8	22.7	14.2	15.0	8.2	7.1
S18	6	6.2	78.3	21.7	58.8	30.7	10.5	38.6	20.2	19.5	11.2	6.2	4.3
Subject H													
M12	3	3.5	70.2	29.8	49.7	31.0	19.3	26.7	23.0	20.5	10.5	10.0	9.3
M18	20	4.0	75.0	25.0	53.3	33.9	12.8	27.3	26.0	21.7	12.2	7.3	5.5
Subject D													
M12	5	5.0	58.5	41.5	39.4	38.3	22.3	23.3	16.1	19.1	19.2	18.3	4.0
M18	6	6.7	64.3	35.7	39.0	40.2	20.8	14.7	24.3	25.3	14.9	7.7	13.1
Subject A													
P12	26	7.1	64.7	35.3	45.8	34.4	19.8	21.2	24.6	18.9	15.5	8.8	11.0
P24	6	7.7	66.1	33.9	42.8	38.9	18.3	15.4	27.4	23.3	15.6	12.0	6.3
Subject C													
P12	20	8.4	55.3	44.7	35.4	40.8	23.8	17.2	18.2	19.9	20.9	13.6	10.2
P18	4	8.0	54.2	45.8	35.2	44.8	20.0	17.4	17.8	19.0	25.8	9.5	10.5
Subject E													
P12	12	4.8	58.5	41.5	34.7	41.5	23.8	15.2	19.5	23.8	17.7	15.6	8.2
P18	3	5.2	69.2	30.8	49.5	34.9	15.6	29.0	20.5	19.7	15.2	6.8	8.8
P36	3	7.0	76.2	23.8	54.9	33.8	11.3	23.0	31.7	21.3	12.5	6.7	4.6
Subject D													
P12	16	9.0	55.8	44.2	33.5	42.3	24.2	13.8	19.7	22.3	20.0	12.3	11.9
P18	5	9.6	59.3	40.7	41.7	33.3	25.0	12.0	29.7	17.6	15.7	17.2	7.8
P36	6	10.5	61.5	38.5	38.7	40.7	20.6	12.9	25.8	22.8	17.9	13.6	7.0

of material is on the average only 1.7 repetitions; there being an average of 5 repetitions for the 12 and 6.7 for the 18 pair material. A decrease of 33 1/3 per cent in the length of the material thus results in a decrease of only 25 per cent in the number of repetitions. This is the only case where the longer material was given after the shorter, but there are a number of other instances in which the effect of practice is eliminated as a factor.

Subject A, after twenty periods of practice on the 12 paired nonsense material, used in the next six periods an average of 6.7 repetitions; following these, six 24 paired nonsense series were learned with an average of 7.7 repetitions. Here then is a case where an increase of 100 per cent in the length of the material required an addition of only 15 per cent in the number of repetitions.

Subject C, after sixteen periods of practice on this 12 paired nonsense material, used in the next four periods an average of 6.3 repetitions; following these, four 18 paired series were learned with an average of 8.0 presentations. An increase of 50 per cent in the length thus required an addition of only 28 per cent in the number of presentations.

Subject D, after eleven periods of practice on this 12 paired material, used during the next five periods an average of 8.1 repetitions; following these, five series of 18 pairs were learned with an average of 9.6 presentations; and following these again were learned six series of 36 pairs with an average of 10.5 repetitions. Thus with an increase of 50 per cent in the length of the material there was an increase of only 18 per cent in the number of presentations, and increasing this material again by 100 per cent of itself resulted in an increase of only 9 per cent in the number of repetitions.

Subject E, after nine periods of practice on this 12 paired material, used in the next three periods 4.7 presentations on the average; following these, three series of 18 pairs were learned with an average of 5.2; following these again, three series of 36 pairs each were learned with an average of 7 repetitions. Thus for this subject there was, with an increase of 50 per cent in the length of the material, an increase of only 11 per cent in the number of presentations; while increasing this material again by 100 per cent of itself there was an increase of only 35 per cent in the number of repetitions.

From these facts it would appear that with an increase in the length of the material there was only a relatively small increase in the number of repetitions required to learn the longer series.

The same fact may be shown by a comparison of the best records made for each length of material. The best record made by Subject A, in the twenty-six series of 12 paired material, was 5 repetitions; while in the six series of 24 pairs he also made a record of 5 repetitions. The best record made by subject C in the twenty series of 12 pairs was one of 5 presentations; while in the four series of 18 pairs one record of 6 repetitions was made. The best record of D in the sixteen series of 12 pairs was 7 repetitions; in the five series of 18 pairs 8 presentations; and in the six series of 36 pairs also 8 repetitions. The best record made by subject E, in the twelve series of 12 pairs, was 3 presentations; in the three series of 18 pairs 4; and in the three series of 36 pairs 6 repetitions.

These facts indicate quite convincingly that the number of repetitions are not proportional to the length of the material in the case of paired associates. In other words, they indicate that one can learn series of 18, 24, and 36 pairs with only a very slight increase in the number of repetitions required for series of 12 pairs each. This does not mean, however, that one can learn these longer series in almost the same length of time, since it takes more time to repeat a series of 18 or 36 pairs than a series of 12 pairs. The actual time may be calculated by multiplying the number of pairs in the series by 8, the number of seconds required to present and attempt to recall each pair of syllables. In the following table, we give the actual time required on the average to reproduce the various lengths for the above subjects. In the table, we have also included the results from two subjects who learned two lengths of the serial nonsense syllables. Av.P. = the average number of repetitions.

TABLE 30

Tabulations of the Average Number of Repetitions and of the Time Required for Materials of Various Lengths.

Length of Material	Subject	Av. P	Time in minutes
Paired nonsense 12	A	6.7	11
Paired nonsense 24	A	7.7	25
Paired nonsense 12	C	6.3	10
Paired nonsense 18	C	8.0	19
Paired nonsense 12	D	8.1	13
Paired nonsense 18	D	9.6	23
Paired nonsense 36	D	10.5	65
Paired meaning 12	D	5.0	8
Paired meaning 18	D	6.7	16
Paired nonsense 12	E	4.7	7
Paired nonsense 18	E	5.2	13
Paired nonsense 36	E	7.0	34
Serial syllables 12	Q	5.4	13
Serial syllables 18	Q	7.7	24
Serial syllables 12	N	4.2	8
Serial syllables 18	N	4.5	11

In the above table, we have the data for only these six subjects, since they were the only cases where, on account of preceding practice, we felt positive that the effect of practice did not enter as a factor. We may add that subject N may have experienced a slight practice effect due to the fact that most of the preceding practice had been upon the number-syllable material. In spite of the limited number of subjects, this table is quite suggestive in that the results in the time required for the various length of material is proportionately uniform for the subjects given.

Comparing the cases where the length of material is changed from 12 to 18 pairs or syllables, we find the time almost doubled for each subject; for subject C it is increased from 10 to 19 minutes, for subject D from 13 to 24 minutes, for subject E from 7 to 13 minutes, for subject Q from 13 to 24 minutes, and for subject N from 8 to 11 minutes. Where the length of the material is increased from 12 to 36 or three times, we find the time increased almost five times; for subject D from 13 to 65 minutes and for subject E from 7 to 35 minutes.

It thus appears, that while the actual time varies for different subjects the relative or proportionate increase in time for the different lengths of material is strikingly uniform.

B. The Effect of the Length of Material upon the Form of the Memory Curve

Turning to our main problem, we find that the table of averages (Table 28), indicates a rather striking uniformity for the curves from the various lengths of each kind of material. A survey of the columns shows, as we have found before, that, while the curves vary a good deal for the different kinds of material, the variations for the different lengths of the same material are comparatively insignificant. At the same time, some features of change are found in the results which, though rather small, are worthy of our consideration.

Table 28 indicates that in every case for all the materials there is, with an increase in their length, a slight increase in the percentages learned in the first half, the first third, and the second sixth of the time or effort expended. This fact would indicate that there is a tendency to increase slightly the percentages reproduced in the early part of the learning in case of the longer material. It will be found, however, upon inspection of the tabulations for individual subjects, that this is true only in nine out of the thirteen cases. (Table 28.) In four cases, we find a decrease in the percentages reproduced during the first half, first third, and second sixth. This variation, connected with the fact that in the case of the averages the increase in most cases are rather small, makes this apparent tendency less significant.

It is clear, both from the table of averages and those of individual subjects, that the general form of the curves is in all cases very much the same for one length of material as for another; in most cases the curves are very much alike even in the smaller details.

If we survey the percentages reproduced by sixths, more variations are found for the different lengths of the number-syllable material than in those of the other materials. Yet these percentages are alike for the different lengths in most respects. In both the 9 and the 12 pair material, the largest percentage is reproduced in the first sixth, and a larger percentage is reproduced in the third than in the second sixth. In the last sixth differences are found for each length which vary for different individuals although the averages for both lengths show a larger percentage of learning in the last sixth than in the fifth sixth.

The two lengths of the serial nonsense material result in almost identical curves.

The four lengths of the paired nonsense material result in curves very much alike. The most characteristic difference is a slight increase in the percentages reproduced in the last sixth as the length of the material is increased.

In case of the meaning material, some differences are found. These differences, it will be observed, are due in the main to the peculiarities found for subject D whose curves for the 18 pairs were quite different from those for the 12 pair material.

Concluding Statements

1. The number of repetitions required to reproduce various lengths of material do not increase proportionately with the increase in the length of the material for paired associates. Whether the length of the material be doubled or trebled only a very slight increase in the number of presentations is required for reproduction. Our data seem to indicate that this is true for all kinds of material.

2. The actual time required for learning is proportionately longer than the amount of increase in the length of the material.

3. The general form of the curves is in all cases very much the same for one length of material as for another, and in most cases the memory curves are very much alike even in the lesser details.

Sec. 5. The Effect of Warming Up and Ennui and the Effect of the Time of Exposure upon the Form of the Memory Curve.

This study was suggested by the possibility that some of the differences, especially those in the first and the latter parts of the curves, might be due to the fact that the subject was at first getting settled and adjusted to his problem or that ennui might influence the learning towards the end or that both these factors might be present in determining the form. For want of a better name, we have used the terms warming up and ennui. It is possible that the form of the curve may change with certain subjective factors; such as, interest, attention, effort, warming up, ennui, and other momentary physiological conditions. If this were true, we should expect to find that, after the subject had been working hard in mastering one series, the curve obtained from a series immediately following would be at least slightly different.

To test this possibility, we gave the subject two series of equal length and of the same kind of material to be learned at one sitting. The second series was given immediately after the first had been mastered. In this way two curves were obtained from each subject at each sitting. Later this procedure was followed with the time of exposure changed from three to one and one half seconds for both series. Our results consequently contain two groups. Group II is the results obtained from curves immediately following those of Group I. Furthermore, these two groups were obtained from some subjects for both three second and one and one half second exposures. In this way results were obtained for two studies at one time. One of these studies, we have, for want of a better name, called the effect of warming up and ennui, and the other the effect of change in the time of exposure.

A. The Effect of Warming Up and of Ennui upon the Form of the Memory Curve.

In table 31, we have first the tabulations of averages from curves of individual subjects in halves, thirds, and sixths of the time or effort expended. Group I and Group II of each subject are placed together in order to facilitate comparison. Following the tabulations for the individual subjects will be found the general averages of the tabulations for each of the groups or series.

These tabulations speak for themselves, and it is evident at once that there is a striking similarity between the curves for the two groups or series. It is possible to say, upon a careful survey of the averages and the individual tabulations, that in series II there is a slight decrease in the percentages reproduced in the first and last sixth and an increase in the second sixth. This difference is so small, however, that we feel justified in saying that in general there is no real difference between the curves for the two series. If the two factors of warming up and of ennui are present they seem to have no appreciable effect upon the form of the curves for these series of material.

In case of the number of repetitions there seems, however, to be a small decrease in the number for the second series. This decrease may, no doubt be attributed to the effect of warming up from the work on the first series.

B. The Effect of the Time Exposure upon the Form of the Memory Curve.

In the former study this question has already been touched

TABLE 31

Tabulations from Curves of Series I and Series II.

M I = subject M and series I.
MII = subject M " " II, etc.
C = the number of curves from which the tabulations are an average.
P = the average number of presentations.

			Halves		Thirds			Sixths					
	C	P	1	2	1	2	3	1	2	3	4	5	6
3 Seconds													
M I	6	5.8	75.3	24.7	55.1	30.8	14.1	33.1	22.0	20.2	10.6	5.4	8.7
MII	6	4.7	77.0	23.0	54.7	36.5	8.8	31.8	22.9	22.3	14.2	6.1	2.7
1 1/2 Seconds													
M I	6	5.2	71.5	28.5	52.4	28.3	19.3	28.5	23.9	19.1	9.2	10.3	9.0
MII	6	4.8	70.6	29.4	54.8	27.6	17.6	28.6	26.2	15.8	11.8	10.4	7.2
3 Seconds													
N I	6	4.2	77.2	22.8	62.8	23.5	13.7	37.0	25.8	14.4	9.1	7.0	6.7
NII	6	3.5	76.3	23.7	61.9	26.4	11.7	33.1	28.8	14.4	12.0	6.8	4.9
1 1/2 Seconds													
P I	6	3.3	73.7	26.3	58.3	25.8	15.9	29.5	28.8	15.4	10.4	8.0	7.9
PII	6	3.7	70.6	29.4	51.8	36.3	11.9	27.0	24.8	18.8	17.5	6.8	5.1
3 Seconds													
O I	6	5.2	69.9	30.1	58.9	22.9	18.2	36.7	22.2	11.0	11.9	11.3	6.9
OII	6	4.7	80.4	19.6	58.8	29.8	11.4	34.1	24.7	21.6	8.2	5.2	6.2
1 1/2 Seconds													
O I	3	6.0	75.0	25.0	55.5	29.4	15.1	38.0	17.5	19.5	9.9	4.8	10.3
OII	3	5.7	71.5	28.5	54.7	28.6	16.7	31.7	23.0	16.8	11.8	13.3	3.4
General Averages													
Av. I	33	4.9	73.8	24.2	57.2	26.8	16.0	33.8	23.4	16.6	10.2	7.8	8.2
Av. II	33	4.5	74.5	25.5	56.2	30.9	12.9	31.1	25.1	18.3	12.6	8.1	4.8

TABLE 32

Tabulations from Curves of 3 Seconds and 1 1/2 Seconds Exposure.
X = Results from the three seconds exposures.
Z = " " " one and one half seconds exposures.
C = the number of curves from which the tabulations are an average.
P = the average number of presentations required for learning.
Y = the results from the six seconds exposures.

			Halves		Thirds			Sixths					
Sub.	C	P	1	2	1	2	3	1	2	3	4	5	6
Series I													
M X	6	5.8	75.3	24.7	55.1	30.8	14.1	33.1	22.0	20.0	10.6	5.4	8.7
M Z	6	5.2	71.5	28.5	52.4	28.3	19.3	28.5	23.9	19.1	9.2	10.3	9.0
Series II													
M X	6	4.7	77.0	23.0	54.7	36.5	8.8	31.8	22.9	22.3	14.2	6.1	2.7
M Z	6	4.8	70.6	29.4	54.8	27.6	17.6	28.6	26.2	15.8	11.8	10.4	7.2
Series I													
O X	6	5.2	69.9	30.1	58.9	22.9	18.2	36.7	22.2	11.0	11.9	11.3	6.9
O Z	3	6.0	75.0	25.0	55.5	29.4	15.1	38.0	17.5	19.5	9.9	4.8	10.3
Series II													
O X	6	4.7	80.4	19.6	58.8	29.8	11.4	34.1	24.7	21.6	8.2	5.2	6.2
O Z	3	5.7	71.5	28.5	54.7	28.6	16.7	31.7	23.0	16.8	11.8	13.3	3.4
P X	10	3.3	69.7	30.3	55.5	29.2	15.3	32.8	22.7	14.2	15.0	8.2	7.1
P Z	6	3.3	73.7	26.3	58.3	25.8	15.9	29.5	28.8	15.4	10.4	8.0	7.9
P Y	1	3.0	69.5	30.5	52.0	35.0	13.0	26.0	26.0	17.5	17.5	6.5	6.5
S X	6	4.7	68.6	31.4	53.6	28.3	18.1	31.7	21.9	15.0	13.3	9.3	8.8
S Z	3	5.5	69.3	30.7	45.8	39.1	15.1	35.5	10.3	23.5	15.6	11.0	4.1
S Y	4	3.2	62.8	37.2	35.7	51.2	13.1	17.4	18.3	27.1	24.1	7.5	5.6
U X	3	2.7	74.2	25.8	56.4	30.8	12.8	28.2	28.2	17.8	13.0	6.5	6.3
U Z	5	4.6	68.3	31.7	51.7	28.8	19.5	29.2	22.5	16.6	12.2	11.8	7.7
U Y	6	2.2	76.4	33.6	56.3	29.3	14.4	28.2	28.1	20.1	9.2	7.3	7.1
General Averages													
X	43	4.5	73.6	26.4	56.1	29.8	14.1	32.6	23.5	17.5	12.3	7.4	6.7
Z	32	5.0	71.5	28.5	53.4	29.5	17.1	31.6	21.8	18.1	11.4	10.0	7.1
Y	11	2.8	69.6	30.4	48.0	38.5	13.5	23.9	24.1	21.6	16.9	7.1	6.4

upon. The problem here was to find out if, by changing the time of exposure, there would be a change in the form of the curve.

In table 32, we have tabulations for comparing curves from exposures of three seconds with curves from exposures of one and one half seconds. Incidentally we have appended the results obtained with six seconds exposure from three subjects. The data for these are, of course, too limited to be of any real significance; furthermore the curves obtained had to be constructed from so few repetitions that they can represent the general trend of the learning in only the most general fashion.

The tabulations from the curves of the three seconds and the one and one half seconds exposure indicate that there is a very close resemblance between them. Nothing like a real uniform difference for all the subjects is found in any of these results. Some slight differences are found for individual subjects, which, at the most, indicate that the changes in the time of exposure effect the curves for individual subjects, if at all, in very different ways.

The number of repetitions, as they appear in the tabulations show that all except one subject required a larger number of repetitions for learning with one and one half seconds exposure than with three seconds. In nearly all cases, however, only a very slight increase in the number of presentations was required for the one and one half seconds exposure; so that in all cases except one, subject U, the one and one half second exposure was the more economical of the two.

Concluding Statements

1. The factors of warming up and of ennui, as measured in terms of comparing two series of curves the second obtained immediately after the first as a warming up series, do not appear to change the general form of the curves.

2. There is a small decrease in the number of repetitions required in learning a series immediately following another which serves as a warming up or practice series.

3. A variation in the time of exposure does not produce any general change in the form of the learning curve; yet it does produce slight changes in detailed parts of the curves for some subjects.

4. The number of repetitions is not proportional to the time of exposure. The number of presentations required for learning differs very little for exposures of three and for those of one and one half seconds. The one and one half second exposure requires a slightly larger number of repetitions but is the most economical of the two, as far as time is concerned, for the majority of subjects.

IV. SUMMARY AND DISCUSSION

Sec. 1. The New Method of Scoring. (See Summary of Part II, Section 1.)

Since no satisfactory nor accurate method of scoring elements or parts of syllables and numbers reproduced was available, we have formulated a new method based on the results of our subjects. We found that the scoring can be made upon the factual or scientific basis of the number of errors resulting from each part or element. Upon this basis it is possible to evaluate not only parts of these materials but elements and parts of other materials and problems as well.

The well known fact, that, in memorizing a series of any kind of material, the first and last part of the series are learned before the parts in between, was found to be true for our experiment. This principle, however, does not hold for parts or elements of syllables or numbers. Here the order is from the first to the last or from left to right; provided, however, that the elements are equally difficult. The order may be changed if one element, like the vowel in a syllable, is less difficult than the other elements.

The striking uniformity found, in the results of our subjects, in the relative number of errors for the various elements in the materials used, is a good example of certain almost universal tendencies of mental function. (Tables 1, 2, 3, and 4.)

Upon a survey of the experimental results found in these tables, certain questions present themselves. Why should the order of difficulty from less to greater be first, second, and third element of the number or syllable? Why should more errors result from the last consonant than from the vowel and first consonant combined? Why should the vowel, as it does in some of the materials, result in less errors than the first consonant?

To the last question our former discussion has suggested a somewhat positive reply. We are not prepared to give a conclusive answer to the first two. More introspective data and more detailed studies will be necessary to answer definitely the why of these questions. Our problems have been problems of what and how rather than why. Still, certain possible explanations suggest themselves. One is the reading habit of grasping elements from left to right. It must be remembered, however, that in reading one grasps words as wholes and the first letter of the word does not necessarily receive the maximum of attention. It seems, therefore, that if this habit should play a part, it can not be taken as a full explanation. The fact that the last consonant is the most difficult suggests that somehow it does not receive the emphasis and attention given to the other elements. Herein, no doubt, will be found the main reason. It seems probable that visual, auditory, and kinaesthetic imagery may give more emphasis to the first part of the syllable. The first consonant naturally receives the most emphasis when the subject tries to tie the syllable to its preceding associate. Visually it is nearer to the associate syllable; auditorily, whether audibly pronounced or not, it with the vowel gives the sound to the syllable; and kinaesthetically it receives the emphasis in the pronunciation of the syllable whether the vocalization be actual or merely felt. Auditorily and kinaesthetically it is very probable that the last consonant receives very much less emphasis than the first. These factors, it seems to us, may be in part the cause of the relatively larger number of errors from the last consonant.

Sec. 2. The New Methods of Grouping, Presenting, and Comparing Results. (See Part II, Sec. 2.)

Our methods of grouping, presenting, and comparing results are briefly as follows:

a. Drawing of graphs or curves from the results of each individual group of material learned or problem mastered. These graphs are drawn such that their abscissae are equal in length no matter how many repetitions are required or how long a time is needed for learning.

b. Having these curves, it is possible to select any common point in each of them and thus compare the fractional parts mastered at various intervals of the learning by comparing the numerical values of these points. The numerical value of any particular point in the curve can be determined by its distance from the abscissa or base line.

c. Tables are constructed in which each curve is represented in numerical terms corresponding to the points of the curves selected for comparison. These points may be halves, thirds, sixths or any other fractional parts of the learning.

d. This method makes it possible to compare curves of any kind by comparing points in which all the effort represented is properly distributed in the graphs of the same.

e. Curves, thus represented, are amenable to numerical computation and statistical methods for various purposes.

This method should be valuable particularly in cases where a large number of curves have to be brought together for comparison and where one may wish to combine a large number of curves into one common curve.

Sec. 3. The Number of Repetitions Required for Learning. (See Discussions and Summaries in Part III, Experimental Results. Sections 1, 2, 4, and 5.)

The facts obtained, relating to the number of repetitions required for learning, were incidental to our main problem; but they are so suggestive and so closely related to it that a brief discussion of them can not be omitted.

The facts adduced from our experimental results, as shown in the study of the effect of practice, Part II, Sec. 1, indicate that there is a very marked reduction in the number of repetitions required for learning after practice. This is in accord with the results of others. In the following table a comparison is made between the results given by Meumann and our own. We have taken the averages from the results of the four subjects reported by Meumann.[1] His subjects practiced on series of 16 nonsense syllables. In the table these can be compared with the averages from our subjects with four different kinds of materials. (See also Graphs, Plates I, II, and III.)

[1] Meumann, E., The Psychology of Learning, page 358.

TABLE 33

	Material	Number of Subjects	Repetitions Before Practice	Repetitions After Practice
Meumann	16 syllables	4	27.0	5.2
Kjerstad	12 syllables	1	18.0	4.0
"	12 Pairs	4	19.0	5.5
"	9 Number-syllable	3	22.0	6.7
"	18 Paired Meaning	2	3.5	2.5

The table shows quite clearly that a very large reduction in the number of presentations does result from practice. The amount it will be seen, depends upon the kind of material learned. In general, we may say that the more familiar the material happens to be the less will be the reduction. Furthermore, while the effect of practice is in a large measure specific for each particular kind of material, it, nevertheless, does have a marked influence upon other materials somewhat similar in nature. For instance, after practice upon paired number-syllable material, the subject will not require so many repetitions for learning paired nonsense material. Subject M is an example of this. (See Graphs, Subject M, Plate III.) This fact shows that the subject is able to carry over a part of the practice effect from one kind of material to another somewhat similar. No one will deny that transfer of this kind does take place. What is carried over in this case is, no doubt, methods or habits of attacking the material to be learned.

In the study of individual differences (Tables 17-25), we found that subjects vary a great deal in the number of repetitions required to reproduce the same material. Some subjects required as much as three times the number of repetitions used by others.

The same lack of uniformity is found in the different kinds of material. (Tables 27 and 33.) The number-syllable material in most cases seems to take from three to four times as many presentations as the paired meaning material. The causes for these differences are, no doubt to be found mainly in the greater complexity and the greater lack of meaning in the number-syllable material.

In the study of the effect of warming up on the number of presentations required, we found that, in learning a series following a warming up or practice series, there was a general tendency to decrease slightly the number of repetitions required for the second series. (See Table 31.) This indicates, what is commonly observed, that it takes the subject some time to get settled down and adjusted to the problem of memorizing before he can learn most effectively each day.

The time of exposure might be supposed to have a very marked influence upon the number of presentations. The results show that it has some influence, but the number are by no means proportional to the time of exposure. (Table 32.) It is clear that changing the exposure from three to one and one half seconds or vice versa results in only a very slight change in the number of presentations. The change in the time of exposure is, therefore, relatively much greater within certain limits than the change in the number of repetitions.

In the study of the effect of the length of the material upon the number of presentations, we found that the number do not increase progressively in proportion to the increase in the length of the material. (Tables 28, 29, and 30.) Here our findings are the very opposite from those reported by Ebbinghaus.[2] Ebbinghaus formulated the law that the larger groups of material require a disproportionately larger number of repetitions. "The number of repetitions necessary for memorization of series in which the number of syllables progressively increased, itself increases with extraordinary rapidity with the increase in the number of syllables."[2] This, it is clear, is the opposite from our facts. Our results force us to agree with Meumann who maintains that the law promulgated by Ebbinghaus does not hold. Meumann's own investigations do not agree with those of Ebbinghaus and he reports that Weber, who worked in his laboratory at Münster "discovered that the law of Ebbinghaus is valid only for unpracticed learners."[3] In the following table, table 34, we quote the results from Ebbinghaus,[2] and those from Meumann,[4] as well as those from our own subjects for four different materials. (See also Table 30.)

[2] Ebbinghaus, I. H., Memory, Ruger translation, pp. 47, 48.
[3] Meumann, E., The Psychology of Learning, p. 275.
[4] Meumann, E., The Psychology of Learning, p. 276.

TABLE 34

Number of Syllables	Ebbinghaus	Number of Repetitions Meumann	Kjerstad Serial Syllables	Paired Syllables	Paired Meaning
7	1.0	—	—	—	—
8	—	5.2	—	—	—
12	16.6	10.4	4.8	6.5	5.0
16	30.0	17.0	—	—	—
18	—	21.5	6.1	7.6	6.7
24	44.0	30.0	—	7.7	—
36	55.0	32.5	—	8.7	—

Ebbinghaus calls attention to the fact that he had the results from only one subject, i.e. himself; Meumann does not state the number of subjects concerned in his results but we take it that there were several; in our own, we have included the results of only two subjects in the serial nonsense material, four in the paired nonsense, and only one in the paired meaning material. We have confined ourselves to this limited number of subjects because they are the only ones for whom we are certain that the practice effect had been eliminated before these results were taken. These results are, however, confirmed by the results of our other subjects who had less practice. (See Table 17-24, 29, and 30.) It is clear, however, that no valid conclusions can be drawn from unpracticed subjects, since the practice effect from one length of material would be carried over to the following length of material used.

It is evident that our results point conclusively to an opposite conclusion to that of Ebbinghaus. With the increase in the length of the material there is only a very slight increase in the number of repetitions required as is shown by the results of our practiced subjects. At the same time, our results are quite different from those in Meumann's table. How are we to explain this difference?

The number of presentations reported in Meumann's table are entirely too large to be from practiced subjects. As already mentioned, we do not know just where or how he obtained them. The only information he gives is found in the sentence preceding his table. "Our pupils are on the whole practiced learners; and with practiced learners we always found a confirmation of the law . . . which may be illustrated by the following data:"[5] After this he gives the tables of results cited above. The expression, "are on the whole practiced learners," seems to indicate that they had not been subjected to controlled practice before the data in the table were obtained. Almost conclusive proof, that his subjects were not practiced subjects is found in his discussion on the effect of practice in which are found the following tables taken from his own text.[6]

The limited number of repetitions shown after practice by Meumann's subjects in both the ten and the sixteen syllable material agree very closely with the number of presentations for our subjects given in table 34. It would seem, therefore, that, if Meumann had used practiced subjects, the 17 repetitions shown for the 16 syllable material should have been reduced to about 5.2 which is the average for his practiced subjects. Our practiced subjects used 6.1 presentations for the 18 syllable material. It is interesting to note that Meumann's subjects used on the average just as many repetitions before practice in the 10 as in the 16 syllable material.

It seems, therefore, that the increase, in the number of repetitions for practiced subjects, is even less in proportion to the increase in the length of the material than Meumann's results would indicate.

It must be remembered that the very slight increase in the number of presentations for the longer materials does not mean that proportionately less time is used for longer material than for shorter. Table 30, from our results, shows that, although

TABLE 35[6]

	Observers	Repetitions: Before practice	Repetitions: After practice
10 Syllables			
	Ba	28	3
	F	23	2
	Br	25	4
	M	31	4
16 Syllables			
	Ba	31	5
	F	19	5
	Br	23	8
	M	34	3

[5] Meumann, E., The Psychology of Learning, pp. 275-6.
[6] Meumann, E., The Psychology of Learning, p. 358.

the number of repetitions are but slightly increased for the longer materials, the actual time taken for learning is proportionately longer than the amount of increase in the series or material. This fact seems to have been overlooked by Meumann in his interpretation when he says: "At the same time, the slow increase in the number of repetitions with the increase in the amount of material reveals the presence of a fact of will, and also perhaps an attitude or adjustment, which may be described by the statement that the expenditure of energy is regulated automatically to conform with the magnitude of the achievement which is demanded of the learner."[7] If Meumann had measured the energy used in terms of the actual time consumed, as we have done, it is doubtful if he would have found it necessary to resort to his "universal law of will" for interpretation. For us there is no longer anything to interpret. Our subjects actually had to use more time proportionately for the longer material, (See Table 30), which is to be expected from a common sense point of view.

More recent and more extended studies of this problem have been made by V. C. N. Henmon[7a] and D. O. Lyon[7b]. A brief statement of their results is found in a recent publication by D. O. Lyon.[7c]

In the following table (Tables C to J) we reproduce their results on nonsense syllables.

[7] Meumann, E., The Psychology of Learning, p. 277.
[7a] Henmon, V. C. N., Journal of Experimental Psychology, Vol. II.
[7b] Lyon, D. O., Relation of Length of Material to Time, Journal of Educational Psychology, Vol. V, 1914.
[7c] Lyon, D. O., Memory and the Learning Process, 1917. Warwick & York.

TABLES C TO J

No. of Syll.	C Meumann Rep.	D Ebbinghaus Rep.	E Henmon Rep.	F Henmon Rep.	G Lyon Rep.	H Lyon Rep.	I Lyon Rep.	J Lyon Time
8	5	1	—	—	—	5	4	¼ min.
10	—	—	7	13	144	—	—	—
12	10	17	8	14	—	69	60	6 mins.
14	—	—	8	15	—	—	—	—
16	17	30	9	15	—	83	67	9 "
18	21	—	11	16	—	—	—	—
20	—	—	14	19	138	—	—	—
24	30	44	13	16	—	94	80	16 "
30	—	—	20	26	—	—	—	—
32	—	—	—	—	—	103	105	28 "
36	33	55	—	—	—	—	—	—
40	—	—	—	—	174	—	—	—
48	—	—	—	—	—	120	107	43 "
72	—	—	—	—	—	306	230	138 "

Tables C, D, and E are averages of several trials—self as subject.
Table F is an average of 3 experiments on one subject.
Table G is an average from 14 subjects—approximate only.
Table H is an average of two experiments on one subject.
Table I approximate only.
Table J taken from Plate I, Memory and the Learning Process by D. O. Lyon.

The table shows, as we have already indicated, that the number of repetitions required in memorizing is quite variable and dependent on a large variety of factors. It is evident that extreme care must be exercised in experiments on this problem if comparable results are to be obtained. The best that can be said at present, it seems to us, is that the number of repetitions and the time taken varies with practice, individual concerned, kind of material, length of material, and other momentary factors.

Sec. 4. The Learning Curves for Memory.

It is not our purpose to attempt a complete interpretation of the forms of the curves obtained. Our problem was to find out whether or not the curves for memory tended towards a common form under changing conditions by introducing as many factors for variation as the limit of our research would permit. We have not begun to introduce all possible factors, but the factors we have introduced will serve as a basis for hypotheses in regard to the probabilities of others.

We have seen that with reference to the number of repetitions the outstanding fact is the fact of variation, change, and difference. Change results from practice, warming up, and modifications in the time of exposure; differences are found for individual subjects, kinds of material, and lengths of material. Contrasted with this, the outstanding facts in our results for the form of the curves are similarity, uniformity, and lack of variation.

If we disregard certain minor variations, we may summarize by saying: that the factors of practice, warming up, the number of presentations, the length of material, and changes in the time of exposure do not have any influence upon the general form of the memory curves. Likewise, the learning curves for individual subjects are similar in their general form though what may be termed accidental variations in detailed parts of the curves may occur. These differences are chiefly individual in character. In one case (See Table 17), three subjects were found to exhibit certain slight variations in the curves which were more or less common to them but different from the curves of the other subjects. The differences, it will be recalled, were hardly sufficient to receive special notice and were it not for the fact that almost the same type of difference was exhibited by three different subjects little significance would have been attached to them. Nothing from the introspective data suggests anything different in the method of learning for these three subjects as opposed to the others.

It appears that the factors given above do not produce changes in the form of the curves, although they do have as a rule a conspicuous influence on the number of repetitions required for learning.

In case of the different kinds of material, however, we have found one factor which does modify the form of the curve. Our results show quite clearly that the form of the curve is slightly different for each of the four or five kinds of material. (See Graphs, Plate IV.) On Plate V, we have constructed the curves for four kinds of material in the usual graphic form. A glance at these will show the reader at once why we have refrained from this method of representing the curves. Even here, where we

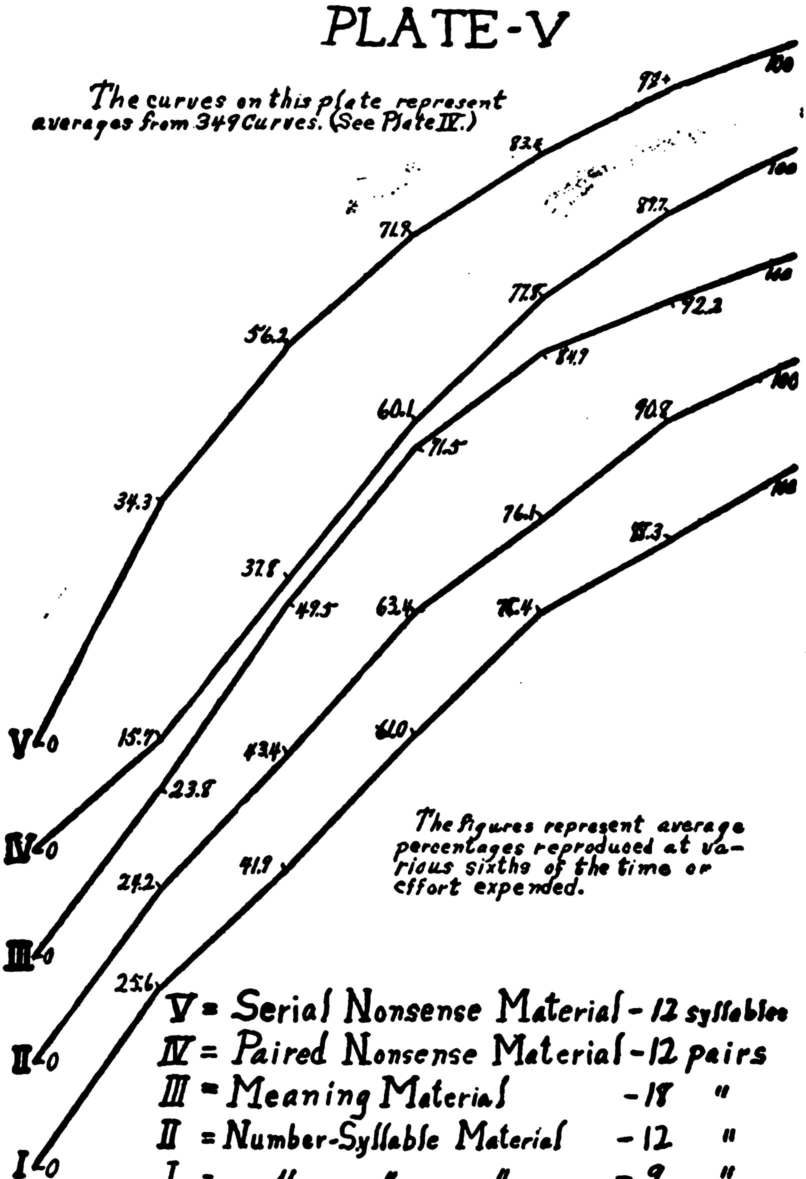


PLATE-V
The curves on this plate represent averages from 349 Curves. (See Plate IV.)
The figures represent average percentages reproduced at various sixths of the time or effort expended.
V = Serial Nonsense Material - 12 syllables
IV = Paired Nonsense Material - 12 pairs
III = Meaning Material - 18 "
II = Number-Syllable Material - 12 "
I = " " " - 9 "
V 0
IV 0
III 0
II 0
I 0
34.3
56.2
71.9
83.6
93+
100
15.7
37.8
60.1
77.8
89.7
23.8
49.5
71.5
84.9
92.2
24.2
43.4
63.4
76.1
90.8
25.6
41.9
61.0
100

maintain that we have a real difference in the curves, it seems that they are so much alike that we may be accused of insisting on too fine distinctions. The reader is referred again to the graphs on Plate IV and the diagrams in Table 26 and Table 27. When comparisons are made in these figures, diagrams, and graphs, the reasons for our maintaining a real difference between the form of the curves for these materials will be evident. *It is not the amount of difference that is significant so much as it is the uniformity with which this occurs for the various subjects and under other varying factors. This fact makes the difference a real, valid, and significant one.* In fact differences, that occur *constantly* under the most varying conditions, are magnified rather than belittled by their minuteness.

Although the main purpose of our study or investigation has not been directed towards accounting for differences, yet some suggestions are pertinent. Unfortunately we have to pioneer in the study of this particular type of learning curves, i.e. memory, and can not get much direct assistance from other sources for interpretation of results.

While little or no attempt has been made to study memory curves, there is a very extensive literature on practice and learning curves of various types. It would not be wise to attempt a review of these at this time. For this the reader is referred to other sources. These memory curves, however, indicate that they have much in common with other learning and practice curves. This is true not only of the general form of the curves but of the factors causing variations in the form.

In a study made of the learning curves for typewriting, we found, as we have found in this study, that the principal factor in changing the form of the curves was the particular kind of material to be mastered. This is an unpublished study (Master's Thesis), made of typewriting curves from four subjects for whom typewriting was a new experience. These subjects carried on practice for a period of one half hour per day for a period of about three months. Ten minutes of this time was given over to practice on a practice sentence, immediately following this twenty minutes were given to practice in taking copy. Two curves were thus obtained from each subject, one from each kind of practice or material practiced upon. In view of the results in our present study of the effect of different kinds of material the following quotations from the summary may be of interest.

"4. There is no correlation between the practice sentence and the copy learning of each subject in gain or loss in speed for the individual practice periods.

"5. There is no significant correlation between the practice sentence and the copy curves in their general features.

"6. There is very little, and on the whole, an insignificant correlation between the practice sentence and the copy learning in periods of rapid advance and periods of little or no advance.

"7. There is no correlation between the practice sentence and the copy learning of each subject, either in kind of errors or in the increase or decrease in the per cent of error for each day's practice.

"8. There is a rather marked correlation between the practice sentence curves of the four subjects in their general course and features.

"9. There is similar marked correlation between the copy curves of the four subjects as to their general course and features.

"10. There is a rather striking correlation with reference to the speed levels at which difficulties occur in all curves."[8]

These results for practice curves of typewriting are interesting in that they show that the kind of material to be learned has a marked influence upon the practice or learning curve for these, just as the kind of material seems to be the principal factor for variation in the memory curves. This suggests that the memory curves have many points in common with the curves for typewriting. The following quotation is as applicable to our present study as it was to that of the results for the typewriting study. "The correlation, found in the results of our experiments, between the curves of different subjects, both as to their general and their periodic features, *indicates that the causes for*

[8] Kjerstad, C. L., A Study of the Form and the Fluctuations in the Learning Curves for Typewriting, p. 43. Univ. of Chicago Library.

these fluctuations must be sought in factors peculiar to the particular type of learning rather than in any changeable physical or mental subjective conditions that may be involved."[9]

Two general features of our curves require specific discussion. These are the initial rise in the curves and the gradual flattening of the curves toward the upper end or what Thorndike calls negative acceleration. These, however, may be said to be one and the same feature, so that they may well be discussed together. Both these features seem to be found in most learning curves. Some exceptions are found, as the ball tossing curves of Swift.[10] The following from our former study is applicable again. "It would appear then, that this rapid initial rise may not be a necessary feature in all types of learning. Furthermore, it may vary with individuals, and always varies with the kind of learning involved. The more interesting fact is that it seems to be more or less similar in learning of the same kind even for different individuals."[11]

Why this rapid initial rise and why this negative acceleration where it does occur in the learning curves for memory?

For some practice curves, fatigue has been suggested as an explanatory factor. This can hardly be a factor in memory curves since one curve obtained immediately after another was found to be similar in form. (Table 31.) Book suggests interest and attention as factors.[12] Again the results found in Table 31 and the variations in the curves for different materials do not indicate such an explanation for memory curves. That under certain conditions they are contributary factors there can be no doubt, but we are quite convinced that in most cases they are minor factors in determining the form of the curves.[13]

Without stopping to comment upon each, the following quotations will serve to bring other suggested factors before us.

"The first rapid and continuous rise is due to the fact that the learner is making progress along many different lines at once.

[9] Kjerstad, C. L., Op. cit., p. 82.
[10] Swift, E. J., Mind in the Making, pp. 174, 175.
[11] Kjerstad, C. L., Op. cit., pp. 68, 69.
[12] Book, W. F., The Psychology of Skill, pp. 99, 100.
[13] Kjerstad, Op. cit., pp. 68, 69.

. . . Every man has experience with the first stages of learning, but little with the later stages because most people touch lightly many things and are masters of nothing."[13]

"It now becomes clear that in so far as the beginning of practice of any mental function means a beginning with the aid from many acquisitions already made in life and from the instinctive bonds that life so far has allowed to act, there are likely to be existing bonds which with slight amendment serve the new function's ends, which will be brought into service early rather than late; and so help to produce the so common early rapid rise."[14]

"The superficial grasp of a few elements that did very good service at first when everything was simple, no longer meets the requirements. The details have greatly increased in number and their loose connection is easily broken. As a result they soon fall into confusion."[15]

The following factors were brought out and emphasized in our former study. "It appears then that we may be making trouble for the future in at least four different ways: (1) by adopting definitely fixed complexes not originally acquired for typewriting use; (2) by adopting useless and wrong complexes; (3) by acquiring smaller and larger complexes which, though useful at a certain stage, become useless and impede the progress in learning in a more advanced stage; (4) by falling into the general habit of writing at a certain more or less definite speed because we do not try to force ourselves ahead."[16]

Each of the above factors are suggestive and, no doubt, play a part in the form of at least some of the learning curves. They also suggest what may be some of the factors for memory curves. In case of these, it is quite certain that the relative difficulty of different parts of the material play a very large part in determining their form. The subject naturally will master the least difficult associations first. In the first presentation, the subject, no doubt, finds certain associations appearing quite readily and these are pounced upon and kept in mind for reproduction. Later the

[14] Thorndike, E. L., The Psychology of Learning, p. 282.
[15] Swift, E. J., Mind in the Making, p. 211.
[16] Kjerstad, C. L., Op. cit., p. 85.

subject has to make use of forced associations and often has to depend upon pure visualization for reproduction. Our introspective data show clearly that in most cases the first syllables reproduced were those for which certain meanings at once suggested themselves to the subject. Most of these naturally came in the early part of the learning. The difference in the curves for various kinds of material strongly suggest this explanation. In case of the number-syllable material, the number elements would be all of nearly equal difficulty. This material, being more homogeneous, would not give opportunity for certain parts to be easily mastered at first and this would result in less negative acceleration, which is exactly what we find. These curves, it will be remembered, approach more nearly to a straight line than the curves for the other materials.

But how are we to account for the novel lack of the "rapid initial rise" in the paired nonsense material which we know permitted more meaning on the whole than the number-syllable material? And why should the most conspicuous initial rise be found in the serial nonsense material?

This, we think, can be accounted for by another factor. It is clear that no effect will be produced upon the score until the learning is complete enough for reproduction. In case of the serial syllables, the subject was permitted to spread his attention and effort upon any part of the series during the presentation, hence he would be able to go back and repeat the least difficult syllable again and again during the presentation, or he could concentrate upon a certain group of syllables. In either case, he would be able to give a good account of himself at the first attempted reproductions. In case of the paired material, however, the subject was commanded to drop each pair from his mind entirely as soon as the next pair was presented and under no conditions to attempt to refer back to any pair or syllable until the associate was presented. This method gives an ideal condition for part but incomplete learning and would result in the poor showing made in the early part of the learning as indicated in the curve.

But, it will be objected, why then do we not have the lack of the rapid initial rise in the paired number—syllable material and the paired meaning material? This question can be answered by interpolating another factor, namely novelty. Words and numbers were not new experiences for our subjects in the sense that nonsense syllables were. Our subjects told us repeatedly that at first some of the numbers were quite easy to remember because they suggested dates, street numbers, or post office box numbers; while others simply had to be remembered by "sheer force" which they contended was an "awful" task when given only three seconds in which to concentrate upon them. In case of the nonsense syllables, it is different. Here each individual of the pair was new to the subject and it required some time before they could be fixed in the mind. The subjects often said that they were just getting acquainted with the syllables. In other words recognition was making itself felt but there was no reproduction.

In these three factors relative difficulty, incomplete learning, and novelty, we may have at least a partial explanation of the forms of the memory curves and their variation for the different kinds of material. To these, we would add at least two more, which are likely most effective for the latter half of the curve. These are wrong associations and what may be called the habit of not being able to recall an associate syllable or number. Very often our subjects habitually associated the wrong syllables, words, or syllables and numbers such that, though they saw the correct associates visually at each presentation, it would not be carried over to reproduction. Consequently, when the test associate was given the habitually wrong syllable was reproduced. So strong was this tendency or habit that occasionally a subject offered to swear to the correctness of his reproduction. It is clear that, due to the repetitions added to correct errors of this kind, a flattening of the curve would result at the end. The other factor, which we have called the habit of not reproducing a syllable or an associate, is also present in the latter half of the learning. This is analagous to what we, in the case of typewriting, called the habit of writing at a certain uniform speed which may be continued for days or even for weeks. In case of memorizing, however, this might be better characterized as the factor of inhibition. The subject seemed to remember that he did not know a certain syllable and had a questioning attitude as soon as the time came for him to reproduce it. He seemed to try to call to mind the missing syllable but failed in spite of his effort. This holding back of one or two syllables or numbers at the end of the learning would naturally lengthen and flatten the curve towards the end.

These are the main factors, as we see them, which may explain the facts of initial rise and of negative acceleration as they appeared in the learning of our subjects, and consequently in the memory curves. *The unusual feature of the most rapid rise appearing near the mid point of the curves, as it does in the learning of paired associates of the nonsense material, may also, as we have seen, be accounted for by the interaction of these factors. At first the result on the score will be small on account of the method of presentation and the consequent partial but incomplete learning, later when the partially learned syllables begin to be reproduced they will be reproduced all along the line resulting in an unusually high score, then as the number of possible means of scoring decreases and inhibitions and wrong associations begin to make themselves felt on the score negative acceleration is the result.*

The factors given above should not be taken as an exhaustive analysis of the *why,* which is subsidiary to our main problem.

In conclusion, we wish to call to mind once more the results between the facts of variation and change as found in the results for the number of repetitions on the one side, and the facts of uniformity and likeness as found in the form of the memory curves on the other.

These facts suggest to us, what probably does not receive enough attention from some of our present day psychologists, that deeply rooted in the human mind, physically or psychically or both, are found certain innate, basic, and *universal common* elements which issue in more or less definite and general modes of functioning; and that upon this, the selective process of experience lays its moulding hand which does putter and change very markedly indeed the detailed mode of expression but cannot modify its innate fundamental aspects.

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An Introspective Analysis of the Process of Comparing

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I. INTRODUCTION

The history of experimental psychology has been a peculiar one, inasmuch as the early experiments were all more or less of a quantitative nature. It has been only recently that systematically conceived and experimentally controlled qualitative experiments have found a place in the psychological literature. Early in the history of this development we find the formulation of the psychophysical methods. From the time of their formulation, they have appeared largely in the experimental literature. The development of the methodology for psychophysics has proceeded along both mathematical and experimental lines until now we have the newer form of the method of constant stimuli, with which the observer is kept in ignorance of the objective relations of the stimuli which he is comparing. There is little advance to be hoped for either from the experimental or the mathematical viewpoint in this method as it now stands.

But very few investigators have raised the questions, as to what is it that we are really measuring with the psychophysical methods and what are the processes involved in such measurements. The few investigators who have raised these questions have failed to make any very systematic attempts to answer them. Our present investigation is an attempt to answer the question regarding the conscious processes which are present in determinations by the method of constant stimuli. We will not be at all concerned in the quantitative aspects of the problem but will be solely interested in a structural analysis and in a functional description of the processes themselves. We have employed several modalities of stimulus and both simultaneous and successive presentations of the stimuli, so that our analysis may be as broad and extensive as possible. In two cases we have employed the identical experimental arrangements which have formally been reported from the statistical side in the experimental literature. Although we have employed the experimental form of the method of constant stimuli throughout our investigation, we believe that our results are of interest for the light that they may throw upon the problem of the processes involved in the process of comparing in general and in the formation of the judgment.

II. HISTORICAL

The analysis of the process of comparing is an ancient problem in the history of human thought. When one attempts to write a short historical outline indicating how this problem has been handled in the past, he finds himself swamped with an exceedingly large and controversial speculative literature. We shall not do more, therefore, than to touch upon a few of the principal ideas which have been advanced.

Aristotle first sharpens the issue by asserting that the process of comparing is carried on in terms of the mental image. This process, as he envisaged it, was exceedingly simple. In the case of the comparison of successive objects, one recalled a concrete image of the first object,—an image of the same modality as the original sensation,—and made a direct and immediate comparison between the recalled image and the present stimulus.

This explanation of Aristotle's was held more or less explicitly or implicitly in most of the philosophical systems from his time until that of Locke. Locke[1] makes the process of comparing even more simple by insisting that discrimination or discerning is a fundamental mental faculty, " . . . whereas it in truth depends upon this clear discerning faculty of the mind, whereby it perceives two ideas to be the same or different."[2] This concept was taken up and is to be found in all of the systems of the so-called "Faculty" psychologists. In Bain,[3] perhaps, we have one of the most comprehensive expositions of this viewpoint. (P. 321): "The primary, or fundamental attributes of Thought, or Intelligence, have been already stated to be, Consciousness of *Difference,* Consciousness of *Agreement* and *Retentiveness*" (Italics Bain's). And again, (p. 325) "what is termed Judgment may consist in Discrimination on the one hand, or in the Sense of Agreement on the other: we determine two or more

[1] *An Essay Concerning Human Understanding.* 1689.
[2] *Ibid.* 22d Edition. London, 1812, Vol. I, pp. 135.
[3] *The Senses of the Intellect.* 3d Edition, London, 1868.

things either to differ or agree. It is impossible to find any case of judging that does not, in the last resort, mean one or other of these two essential activities of the intellect."

These, then, are the two great opposing concepts which have appeared before the purely experimental attack on the problem. We find, in surveying the experimental literature, a great deal of confusion, largely in the matter of terminology. We frequently find, even in the later experimental literature, an equality judgment spoken of as a recognition; and indeed even the expression "the recognition of difference" is to be met. Also the entire literature on judgment could be included under our topic, although there is much material here that does not have to do with the process of comparing *per se*. All of which is merely another indication of the rather obvious fact, when dealing with the higher intellectual processes, that it is extremely difficult to set exact limits to the field of endeavor. Only by a series of abstractions can one survey one of these intellectual processes in isolation from the others. We shall deal in this summary only with those experimental studies which bear directly upon our present problem.

Let us first consider very briefly the studies of the recognitive consciousness. This becomes necessary because it may be argued that the process of comparing which leads to a judgment of similarity may indeed be in the nature of a recognition. The Lehmann-Höffding controversy in this regard is exceedingly well known. Lehmann,[4] on the basis of certain experiments asserted that a reproduced image was necessary for a recognition. Höffding[5] denied this and insisted that the recognition may be immediate and that it is characterized by a quality of known (*Bekanntheitsqualität*). Most of the later experiments have been aimed at one side or another of this controversy.

Turning now to the experimental studies bearing more directly on our problem, we find very few significant papers. This is particularly surprising when we consider the vast amount of experimental work which has been done with the process of com-

[4] Ueber Wiederkennen. *Phil. Stud.*, V., 1889, 96-156.

[5] Zur Theorie des Wiederkennens. *Phil. Stud.*, VIII., 1893, 86-96.

paring. All of the quantitative work which has employed the psychophysical methods in the field of sensation has made use of this process. But the interest of the workers has been in the quantitative aspects of the problem rather than in the qualitative analysis of the process itself. Indeed very few of the workers in the field have attempted a real introspective analysis of this process under properly controlled conditions. Several investigators have recorded introspections more or less systematically as a mere bi-product of their quantitative work.

Fechner[6] held a view which differed considerably from the Aristotelian concept of the comparing of an image of a former experience with the present sensation in the formation of a judgment of difference or similarity. Fechner's work, in the field of lifted weights, had to do largely with the quantitative aspects of the problem and his qualitative analysis was purely incidental. He seized upon the concept of the "innervation sense," then currently accepted, and made this fundamental for his concept. We do not compare, says Fechner, the images of the sensations of the stimuli but rather the amount of innervation of the muscle necessary to lift the weight.

Müller and Schumann[7] with a carefully planned experimental arrangement made an investigation which led them to attack this concept. The theory of the innervation sense had fallen more or less into disrepute by this time. These authors believe that both stimuli are lifted with the same motor impulse. Hence the lighter weights will be raised relatively more quickly and the heavier stimuli will be raised less quickly. Therefore these authors believe that the speed with which the comparison stimulus is lifted is the primary factor in the formation of our comparison judgments as well as in the formation of our judgments of absolute weight. They find confirmatory evidence for this view in the abnormal literature. Hence although pressure sensations may form a part of our judgments still the kinaesthetic group with special reference to the speed of lifting is of primary importance.

[6] *Elemente der Psychophysik,* 2d Edition, Leipzig, 1889.

[7] Ueber die psychologischen Grundlagen der Vergleichung gehobenen Gewichte. *Arch. f. d. ges. Physiol.* (Pflüger), XLV., 1889, 37-112.

Fullerton and Cattell[8] believe that their experiments refute the statements that either the speed of the movements or the extent of the movements plays an important part in our comparing of weights. They believe that the chief factor in judging is that the subject holds each stimulus with just enough force to keep it from slipping out of his fingers, and hence the factors in judging are partly cutaneous sensations of the fingers against the weight and partly muscular sensations in the fingers.

Martin and Müller[9] follow the concept expressed by Müller and Schumann and extend it by further experimentation in the field of lifted weights. They emphasize the type of comparison which the former authors announced and crystallize and clarify this still further. The authors say that the subjects approach the second weight with a motor set (*Einstellung*) occasioned by the lifting of the first weight. Then when the second weight is lifted in the presence of this motor set or preparation the stimulus goes up more or less rapidly, and the awareness of this gives rise to our judgments of difference. These authors also emphasize the influence of the absolute impression of each of the stimuli, which seems to be present to consciousness in tactual and kinaesthetic terms, and which for these authors is an immediate experience. With Martin and Müller we have the first real attempt at anything like a careful introspective analysis. For example, they note individual differences between their subjects; for Observer Jost, the absolute impression seemed to be an immediate kinaesthetic-tactual awareness; while for Observer Henri, there was a mediating visual schema and each group of kinaesthetic sensations was placed in this visual schema before the absolute judgment was given.

Kinnaman[10] analyses the consciousness for the comparing of lifted weights still further. He insists that there is a great complex of sensations but that in each lifting one of these is focal and the rest are marginal. For non-intensive stimuli, the focal sensation is apt to be of tactual modality, while for more intensive

[8] *On the Perception of Small Differences.* Philadelphia, 1892.

[9] *Zur Analyse der Unterschiedsempfindlichkeit.* Leipzig, 1899.

[10] A Comparison of Judgments for Weights Lifted with the Hand and Foot. *Amer. Jour. of Psychol.*, XII., 1900, 240-263.

stimuli this focal sensation, which seems to be the basis of the comparison, is of a kinaesthetic sort. If kinaesthetic criteria are employed, Kinnaman believes that the judgment is made on the basis of the sensations at the very beginning of the lifting of the second stimulus. The overcoming of inertia to start the weight from the table seems to be the important factor. Hence the judgment is made from the time that the lift is started until the time that the weight leaves its support, rather than from the totality of sensation when the weight is at the top of the lift. "From our standpoint, the basis of judgment appears to be the memory of a former change of sensation as compared with the present changing sensation" (p. 257).

Angell[11] working with the comparing of shades of gray as his materials makes several interesting contributions. He used various time intervals between his stimuli, ranging from 5 to 60 seconds. "As regards the reactions for 5 seconds, it has been observed that the demeanor of the subjects for the shorter intervals is commonly, though not invariably, different from what it is in the longer. In the 30 and 60 second intervals, the subject is apt, soon after the exposure of the norm, to relax the trunk muscles, settle himself in an easy attitude, to breathe easily and to move the eyes from time to time over the background. During the shorter periods, the subjects usually try to maintain uniform sensory conditions for both norm and comparison stimulus, the tension sensations from the trunk, respiration and eye muscles are kept constant in order apparently to make the conditions as much alike as possible. Accordingly we have, for most subjects, a much larger mass of background of sensation entering into the comparison of shorter intervals and, in all probability, more genuine acts of comparison" (p. 18). Angell also emphasizes a type of judgment which consists merely in a verbal characterization of the stimuli.

Hayden[12] also emphasizes this fact of the verbal characteri-

[11] Discrimination of Shades of Gray for Different Intervals of time. *Phil. Stud.*, XIX, 1902, 1-21.

[12] Memory for Lifted Weights. *Amer. Jour. of Psychol.*, XVII, 1906, 497-521.

zation of the stimuli and believes it to be the important criterion. Hayden deals with lifted weights and the verbal characterization was of the absolute weight of his stimuli. Hayden also finds that judgments of similarity are of a negative character, *i.e.* such as the subjects make when the criteria for the other judgments are lacking. He finds that there is an uncertainty in making judgments of this sort, which shows itself especially in a lengthened reaction. Hayden, then, accepts the Müller and Schumann concept of a motor set or adjustment in the presence of which the second stimulus is lifted. He insists, however, that the impulse of this adjustment is largely a verbal image which gives the position of the standard weight in a scale of values.

Angell[13] takes up this matter of the negative character of the equality judgment, working in the field of sound intensities. He finds that several factors are present. The type of subject is an important factor, *i.e.* whether he is impulsive or deliberate. The course of the experimentation also has a bearing, *i.e.* whether the series contains many or few difficult judgments. Also the time interval between the stimuli is important in this respect because, with the shorter time intervals, the subjects can maintain more constant bodily conditions for comparing. The point Angell strongly emphasizes in this paper is that, in early stages of practice, the judgments of similarity are usually of a negative character, *i.e.* the subjects fail to note a difference between the standard and comparison stimuli, and hence these judgments are hardly distinguishable from the doubtful judgments. In the course of time, however, this absence of difference becomes a positive mark and, in this stage of practice, equality judgments are given with a great degree of conviction. Angell conceives the structural basis for this transition in the following way. (P. 259): "In the first place, most of the judgments of like in the early stages must be excluded as inferences. . . . They quickly become more and more syncopated and condensed until they exist as an abstract state of knowing (*Bewusstheit*),—abstracted, that is, from any background of imagery or sensation." "In the present

[13] On Judgments of "Like" in Discrimination Experiments. *Amer. Jour. of Psychol.*, XVIII, 1907, 253-260.

investigation, the decision on the comparative loudness of the sounds became practically a reaction or response to the second sound in terms of 'louder,' 'softer' or 'like.' These terms, or some abstract equivalent of them, were 'nascent' to use a Spencerianism and when the comparison sounded, it was immediately thought of as under one of the categories. Occasionally it was classified by means of some sensory sign,—resonance for example,—but usually the classification resulted without sensory or ideative basis."

We come now to two papers in which the introspective analysis is featured, although quantitative aspects of the problem engage the attention of the authors to a very great extent. In these two papers, for example, the actual introspections of the subjects are given with much greater frequency than in any of the studies which we have summarized. Bentley[14] employed visual brightnesses (grays) and colors as his materials. His method was to expose a color and then, after a distraction period of varying length up to five minutes, to ask his subject to call up a visual image of this color and then compare it with the stimulus which was shown again. Bentley emphasizes the fact that as simple an object as a gray permits of a noteworthy latitude of the modes in which it may be recalled. An individual of predominantly visual type may recall the first stimulus as a direct concrete visual image. But names or verbal descriptions are not entirely excluded and become of primary importance where the verbal type of memory is strong and the visual deficient. Also strain sensations about the head and in the trunk with, perhaps, general bodily sensations seem to facilitate retention and comparing in certain cases.

Whipple[15] still further emphasizes the qualitative aspects of the problem. He employed clangs and tones as his stimuli. Whipple also emphasizes very strongly the fact that the image of comparison need not be of the same modality as the original

[14] The Memory Image and Its Qualitative Fidelity. *Amer. Jour. of Psychol.*, XI, 1899, 1-48.

[15] An Analytic Study of the Memory Image and the Process of Judgment in Discrimination of Clangs and Tones. *Amer. Jour. of Psychol.*, XII, 1901, 409-457; XIII, 1902, 219-268.

stimulus. Also many immediate judgments may take place in which there is apparently no trace of an image of any sort. Great individual differences are noted by Whipple between his different subjects. Kinaesthetic and visual factors may form the basis of the comparison process as well as the auditory, or any combination of these modalities may be present. Let us quote Whipple. (Pp. 259 f.): "The presence of the auditory image is not necessary to the recognition of either difference or equality. Judgments without the slightest trace of comparison are so frequent as to be the prevailing type for most observers. . . . The auditory image may be present in the judgment consciousness but not of itself an object of attention, not serving as a basis of comparison. This is most common in judgments of identity which tend to be immediate. The auditory image may be an essential componant of the judgment consciousness, becoming a direct object of the attention, after the attention has once been given to the variable. Such judgments exhibit a true process of comparison. Judgments of higher and lower made without conscious reference to the (auditory) image, are largely analysable into complexes of strain sensations with less prominent visual and organic elements, set free neurologically by the variable stimulus. The two chief factors, feelings of tightening and relaxation for higher and lower respectively, were reported throughout the tests with discrete tones. These strains were especially noticeable in chest, throat, eyebrows, scalp and about the ears. Judgments of equality or identity without the presence and use of the auditory image are not so frequent as judgments of difference. Usually in the equality judgment there is an alternation of images and a real comparison."

This summary does not attempt to be exhaustive with regard to the experimental literature which is more or less related to our topic. We believe, however, that it is representative of the principal viewpoints which have appeared in the literature. In general, then, the old concept advanced by Aristotle of the process of comparing as a direct comparison of a concrete image of one stimulus with the sensation of another has been enlarged to a very considerable extent. Most investigators attest the presence of the immediate judgment, which is variously explained as being of the nature of an absolute judgment, or as being an immediate and direct 'knowing.' Also it has become recognized that imagery of modalities other than that of the standard stimulus may be of very great importance in the formation of a comparison judgment. The kinaesthetic and verbal forms of imagery have been emphasized in this regard.

III. METHODS AND MATERIALS

Our experimental investigation of the process of comparing was carried on in the Laboratory of Experimental Psychology, Clark University during the winter and spring of 1913, and throughout the academic year of 1914-1915.

The subjects who kindly consented to act in these experiments were Miss E. Bowman (B), Mr. H. R. Crosland (C), Mr. E. O. Finkenbinder (F), Miss S. C. Fisher (Fs), Mr. F. J. O'Brien (O) Mr. D. I. Pope (P), Mr. G. S. Snoddy (S), Mr. R. B. Teachout (T), Mr. R. H. Wheeler (W), and Miss E. L. Woods (Wd). All of these were graduate students in experimental psychology and all but two of these subjects had considerable and extensive training in the handling of the method of systematic experimental introspection. The two subjects who lacked this training (B and T) had had a good deal of experience in psychological procedure and experimentation, and also acquired an introspective training rapidly during the progress of the experiment.[1]

The experiments were divided into four parts, the materials for each part appealing to a different sense modality. In the first part of the experiment, we employed lifted weights as our materials, and worked intensively upon this series during the winter and spring of 1913. During the year 1914-15 we employed as our experimental materials for the process of comparing short lengths of lines, noises, and finally a series of grays. In the first part of the experiment with lifted weights the subjects employed were F., Fs., P., W., and Wd. In our experiments with noises and short lengths of lines, B., C., Fs., O., S., T., and W. acted as subjects. In our last series of grays the subjects were B., C., Fs.,

[1] I wish to take this means of expressing my gratitude to those who acted as observers in this investigation and for their efficient and willing coöperation. I take this opportunity also of expressing my deepest gratitude to Prof. J. W. Baird for suggesting this problem and for his many suggestions during the experimentation.

O., S., and T. All of the subjects were entirely naïve as to our particular procedure of presentation of stimuli at the start of each series of experiments.

Procedure: The criticism against the method of experimental systematic introspection has been made that the materials presented in the earlier experiments which used this method were so different from exposure to exposure that they failed to arouse similar states of consciousness. In order to overcome this criticism we employed throughout the strictest form of the method of constant stimuli in the presentation of our materials. This method undoubtedly overcomes this very criticism in a better manner than any other method of presentation of material. By means of the employment of this method we had also hoped to obtain quantitative data which might perhaps throw some light upon the questions of present interest. In this, however, we were not entirely successful, because we could not obtain a sufficient number of judgments to be properly treated statistically, and our qualitative findings will be alone discussed in the present paper.

As regards the particular method for the experiments with lifted weights, our procedure was exactly similar to that developed by Urban.[2] The weights were hollow brass cylinders two and one-half inches in diameter and one inch high, open at one end. They were filled with solder which was then scratched out until the weights had the proper intensity. Our set of weights, although carefully tested, did not show in any case a variation as great as ten milligrams throughout our experiment. These weights, fourteen in number, were placed about the circumference of a table with a revolving top. Seven of the weights were standard stimuli of one hundred grams, the other seven formed a comparison series from eighty-four to one hundred and eight grams in steps of four grams. By means of the turning-top table, the stimuli could be brought in succession directly under the hand of the subject, and hence all space errors were eliminated. The time errors were always in the first order,—

[2] F. M. Urban, *The Application of Statistical Methods to the Problems of Psychophysics*, Philadelphia, 1908, pp. 1-6; S. W. Fernberger, On the Relation of the Methods of Just Perceptible Differences and Constant Stimuli, *Psychol. Mono.*, No. 61, 1913, pp. 6-11.

that is, the standard weight was always lifted first. The subject was seated comfortably at a table which supported his right arm, the hand hanging over the edge and passing through an aperture in a screen which veiled the stimulus table entirely from view. The lifting of the weights was regulated by means of a metronome which beat ninety-two times per minute, every fourth beat being accentuated by the ringing of a bell. The lifting of every weight required four beats of the metronome. After every second weight was replaced the subject gave immediately and verbally a judgment, by expressing a single word. The categories of lighter, heavier and equal were employed. A heavier judgment indicated that the second weight of every pair was subjectively heavier than the first weight of that pair. A lighter judgment indicated that the second weight of each pair was subjectively lighter than the first weight. The category of equality judgments included not only those cases of actual subjective equality, but also all cases in which the subject was unable to tell whether the second stimulus was lighter or heavier than the first stimulus,—so-called 'doubtful' cases. It is needless to say that the subjects did not have any knowledge of the objective relations of the stimuli.

At every sitting we presented to each subject a series comprising five complete revolutions of the table,—that is, five judgments on each of our comparison pairs, or thirty-five judgments in all. In this series the subjects were instructed not to give introspections. We then presented what was termed the introspective series. In this latter, one pair of weights was presented to the subject, which were lifted in the proper rhythm, and upon which a judgment was given. A second pair was immediately presented in the proper rhythm upon which a judgment was again given. Then the experiment was immediately stopped and an introspective description was given by the subject of everything that appeared in consciousness from the time of the giving of the judgment upon the first pair of weights. By the presentation of the first pair we hoped to have our conditions as nearly similar as possible to those of the actual non-introspective series, that is, this first pair was given as a 'warming-up' pair, so that the hand movements might become as automatic as possible. In this way we obtained an introspection at each sitting upon each of the seven stimuli in our comparison series. At the end of this introspective series we again presented to the subject a series of five rounds of the table without introspections.

With this procedure and these materials we hoped to be able to obtain an introspective account of the process of comparing for an easy lighter and a difficult lighter, an easy heavier, a difficult heavier, an actually equal, and finally a doubtful judgment. We introduced the series without introspections in order that the process of mechanization might progress more rapidly until the process of comparing became as automatic as possible. It is with this in view that we have planned all of our comparison series. In the series of lifted weights we obtained twenty-five introspections on each of our comparison pairs from each of our subjects.

Our series in the comparison of small differences in the lengths of short lines, was exactly a duplication of that employed by Maxfield.[8] The standard lines were printed in black four-point type, 150 printer's points long. The comparison series of the same width of line varied from 144 to 156 printer's points, in steps of two printer's points. These lines were printed on separate cards, three and one-half by twelve inches, each line being separated by one inch of the white card. These seven cards were placed on a revolving drum (see Maxfield, *ibid,* pp. 2 and 3) by means of which each card was brought to rest for approximately one and one-half seconds behind an opening two and one-half by ten inches, cut in a black fixation screen. The standard stimulus was always to the left, the comparison stimulus to the right. Hence the space error was in the first order, the time error being constant. The subject was instructed to give a judgment in terms of the three categories longer, equal and shorter, these categories being defined as previously. A non-introspective series of five judgments upon each comparison pair was obtained at the beginning of the sitting. Following this an introspective series was

[8] F. N. Maxfield, an Experiment in Linear Space Perception, *Psychol. Mono.,* No. 64, 1913, pp. 1-5.

used in which the subject gave an introspection upon his formation of the judgment for each one of the comparison pairs. In this the subject was instructed to fixate the pair then in view, and to make a judgment upon the next pair which came in front of the aperture. The experiment was then stopped and the subject was asked to give a complete introspective account of what had occurred in consciousness during this entire procedure. This was followed by a non-introspective series of five judgments on each of our comparison pairs at the close of each sitting. Ten introspections on each of our comparison pairs were obtained from each of our subjects.

In the sound experiments we utilized the sound pendulum as our material. The standard stimuli were obtained by allowing the hammer to fall upon the ebony block through an angle of 50°. The comparison stimuli were obtained by raising the hammer from 35° to 65°, in steps of 5°. The subject was seated behind a screen so that he was unable to see the manipulation of the hammers. Approximately one second elapsed between the standard and comparison noises, and one second between pairs. Immediately after the comparison stimulus, the subject was asked to give a judgment by vocalizing a single word, in terms of the three categories louder, softer, and equal, as before defined. At each sitting we obtained a non-introspective series of five judgments on each of our comparison pairs. This was followed by an introspective series of one judgment on each of our comparison pairs and then by a non-introspective series of five judgments on each pair at the conclusion of the sitting. In our introspective series, after a ready signal, the standard and comparison stimulus upon which we wished an introspection were given and the experiment at once stopped, and the introspection taken. After carrying through five such series, we gave to each subject a rather long practice series of two hundred judgments on each of our comparison pairs. This was followed by five more series with introspections. By the introduction of such a long practice series we hoped to obtain a picture of the process of comparing at a very high state of mechanization, a higher state, indeed, than had been reached in any of our other experiments.

Finally we employed a series of grays as our comparison material. Each pair consisted of a standard gray (number 27 of the Hering set) and comparison grays numbering 17, 20, 28, 27, 30, 37 and 38 of the Hering set. We find it impossible, by means of photometric readings, to obtain a series of grays with equal distances so we merely chose certain grays which we believed would give us energetic comparison consciousnesses of easy and difficult, lighter and darker, of equal and of doubtful judgments. Each stimulus was a rectangle one and one-half by two inches. These were presented by means of the revolving drum used in our experiment in the comparing of the length of lines, so that every pair was present before the aperture about one and one-half seconds. The standard gray was always to the left, the comparison gray to the right, hence the space error was in first order, the time error being eliminated. As soon as possible, the subject was required to give a judgment in terms of the left-hand gray in accordance with the three categories already described. In this experiment also, we employed at each sitting a non-introspective series of five judgments upon each pair, which was followed by an introspective series of one judgment upon each pair, and this again was followed by a non-introspective series of five judgments on each pair. In the introspective series, the subject at a ready signal was told to fixate the grays which appeared in the aperture and to give a judgment upon the next pair which appeared. Then the experiment was immediately stopped and an introspective account taken of the formation of this judgment.

It will be noticed that by these procedures we have appealed, we believe, to at least four modalities of perceptive discrimination. The lifted weight series which should appeal largely to the tactual and motor; the series on the length of lines should appeal largely to the visual, both kinaesthetic of eye-movement and retinal; the series with sounds appeals primarily to auditory discriminative ability, while our final series of grays should appeal more largely to purely rentinal factors. It will furthermore be observed that we have employed both simultaneous and successive presentations of our discriminative material; the stimuli of the lifted weight and sound series being given in successive fashion, while the series of length of lines and the series of grays were given in strictly simultaneous fashion. By this means we hoped to obtain an introspective description of the content of consciousness and the mental procedure of the process of comparing under these two very different means of presentation of material to consciousness.

IV. RESULTS

1. *Introspections*

In this section we present typical introspections obtained from each observer in each series of these experiments. It will be observed that a serial number appears at the beginning of each introspection to the left of the date. This is a purely arbitrary number which is inserted here for convenience in subsequent reference. The series number, which appears next to the right, refers to the day upon which this introspection was obtained. Hence "Series IV" would indicate that this introspection was obtained during the fourth day of experimentation for this observer upon this particular experimental series. Next to the right appears the date upon which this particular introspection was obtained. Then appears the intensity of the comparison stimulus, and finally the judgment given by the observer. This is followed by the introspection as it was dictated by the observer.

Observer *W*.

The Comparing of Lifted Weight Stimuli

1. Series I. 2/19/13. *88*. 'Lighter.' "When I lifted the first weight I was aware of pressure sensations on thumb and fingers and also of the pulling of the weight upon the muscles. This sensation was very similar to the tactual sensations and was localized vaguely in the joints of the fingers and the knuckles, also extending somewhat into the wrist. Attention fluctuated from these sensations to a visual image of my hand and of the weight which, however, was not very clear. An image of a tactual and kinaesthetic sort of the first weight remained in consciousness during the lifting of the empty hand and up to the grasping of the second weight. Almost immediately upon the lifting of the second weight I noted that the pressure sensations on the fingers were not so intensive nor were the kinaesthetic sensations of pull so intensive as the images of the first weight of which I had been aware a moment before. I then had a visual image of a weight, small and light in color and somewhat to the right, while to the left I had a visual image of a weight, large and very yellow. These images were respectively of the second and first weights."

2. Series I. 2/19/13. *92*. 'Lighter.' "The first weight seemed absolutely heavy, due to very intense pressure on the fingers and intensive pull on the

muscles and joints of the hand. Of these two factors the pressure sensations were the more clear and seemed to be the more important. I then had a visual image of a weight and of my hand grasping it. These processes were attended to very keenly. When the second weight was lifted I was surprised that it was so much lighter. The weight appeared to come up very easily. This is the first time that I have noticed a preparation of the muscles to lift the weight as I had apparently expected a heavy one. I am unable to give any content of consciousness to account for this preparation. The first thing I was aware of was the ease of lifting. I noticed in kinaesthetic terms that the weight came up more rapidly and I later visualized this rapidity of movement. I began to introspect before the weight was returned to the table."

3. Series II. 2/26/13. *100.* 'Heavier.' "The weights and the table were visualized before the first weight was lifted. I was very clearly conscious of the pull on the muscles and joints of the hand, and also of muscular sensations in the upper forearm during the lifting of the first weight. There was also in consciousness sensations of pressure on the weight and also of movement in the wrist. When the weight was lifted to the top of the stroke I was conscious of stretching the skin, particularly about the knuckles. These sensations, however, were very diffuse. These sensations were all very clear and relatively intensive. The sensations, particularly those of pressure of the fingers on the weight and the kinaesthetic sensations in the upper forearm, were present to consciousness throughout the lifting of the empty hand and up to the grasping of the second weight. All of the sensations just mentioned were present during the lifting of the second weight and I was aware of very intensive sensations, particularly in the upper forearm and in the fingers. I then visualized both weights, the first weight to the left, the second weight to the right. Both weights were of the same size and color but the weight to the right was lower than the one to the left."

4. Series III. 3/5/13. *104.* 'Heavier.' "The first weight seemed very heavy, which brought about an increased concentration of attention as well as a visualization of the process. I was aware of tactual sensations from the fingers which attracted attention, and all other factors apparently went out of consciousness, with the possible exception of the kinaesthetic sensation in the forearm. I then had a very clear visual image of the first weight in air as well as an image of the kinaesthetic and tactual factors which were present throughout the lifting of the empty hand. Then the second weight was lifted and I was conscious of the same tactual and pressure sensations on the fingers, and later I was conscious of an increased pulling down in kinaesthetic terms, localized in the fingers and wrist. I then visualized the second weight as lower and nearer to the table than the first weight. The second weight was also visualized as solid and the first was visualized as translucent."

5. Series III. 3/15/13. *100.* 'Heavier.' "Just before the first weight was lifted I was aware of strain in the forehead and eyelids. I did not visualize

the weights as they were presented to me. The first weight was picked up and I had a very clear tactual sensation of the pressure of the fingers on the weight, this time without any visualization of this process. I was then aware of very clear kinaesthetic sensations in the wrist and upper forearm during the lifting of the weight, and these again were not visualized. As far as I am aware, I made no judgment of the absolute weight of this stimulus. I then had a visual image of the second weight approaching, but this was very dim and hazy and without clear outlines. Just before the second weight was grasped I had a very clear tactual and kinaesthetic image which I referred to the first weight in a visual spatial manner toward the left. The second weight was grasped and as I started to lift it it nearly slipped from my fingers. I was then conscious, in terms of more intensive tactual sensations, of grasping this weight more strongly. When this second weight was at the top of the lift I was conscious of more intensive kinaesthetic sensations in the knuckles and muscles of the upper forearm. I then had a visual image of two weights, the one to the right being closer to the table than the one to the left."

6. Series V. 3/18/13. *100*. 'Equal.' I visualized the general experimental situation in the fore-period. The first weight was lifted and I was aware of kinaesthetic sensations in the knuckles, wrist and forearm, and pressure sensations on the fingers. The first weight was replaced and consciousness seemed to be filled with an effort to recall the intensity of the first weight in visual, kinaesthetic and tactual imagery. The kinaesthetic image, particularly in the wrist, was present but was not clear. Then this was followed by unpleasantness and great strains in the forehead. The second weight was lifted and I was aware of pressure sensations on the fingers and the kinaesthetic sensations, particularly from the wrist. While lifting the second weight there was an effort to recall the kinaesthetic image of the lifting of the first weight. When the second weight was at the top of the lift I had a very clear kinaesthetic image of the lifting of the first weight, which appeared to be of exactly the same intensity as the sensations from the second weight. The whole situation came in at this time in visual terms,—that is, the image of the first weight was referred in a visual spatial manner toward the left, while the sensations from the second weight were referred in a similar manner toward the right. I do not believe that the sensations of the second weight and the image of the first weight were ever present exactly simultaneously."

7. Series IV. 3/12/13. *88*. 'Equal.' "This was a case of real subjective equality. I visualized the table and the weights in the fore-period. When the first weight was grasped there was a great increase in attention, which was followed immediately by a clearing up of my visual image, which now became very definite. When the first weight was grasped I was conscious of pressure sensations in the fingers and kinaesthetic sensations in the knuckles, and especially in the wrist and forearm. These bodily parts were then visualized for an instant. With the lifting of the weight there was a sudden rise in intensity and clearness of the kinaesthetic sensations. Between the lifting of the first and second weights there were very clear kinaesthetic images in the muscles of the hand and wrist, which remained rather constantly up to

the lifting of the second weight. When the second weight was lifted all of these tactual and kinaesthetic sensations were present, and as far as I can tell, they were of the same intensity as the images just preceding. I then visualized the equality in terms of two weights of the same size, color and the same distance from the table."

8. Series V. 3/18/13. *88.* 'Lighter.' "In the fore-period I visualized the experimental situation very clearly. In this period the clearness of the visual image seems to be correlated with the concentration of attention. When I lifted the first weight I was conscious of sensations of a kinaesthetic sort in the upper forearm, wrist and knuckles, and of tactual sensations on the ends of the fingers. These pressure sensations, however, were non-focal. During the lowering of the first weight I visualized the process. When the empty hand was raised there was a very clear kinaesthetic image of lifting the first weight, which persisted up to the lifting of the second weight. When the second weight was lifted there was a definite lack of fulfilment of the image and the hand went up quickly and suddenly. This was followed very rapidly by pleasantness and surprise, which later I am unable to analyze. A visualization of the situation did not come until very much later, —indeed, after I had verbalized my judgment."

9. Series XII. 5/3/13. *88.* 'Lighter.' "I visualized both weights and the table in the fore-period. With the grasping of the first weight, the tactual sensations on the tips of the fingers were present but for a short time only. With the lifting of the first weight muscular sensations were very clear in the upper forearm and slightly in the wrist. I was not aware of any sensations in the fingers or knuckles. The first weight was judged to be absolutely heavy in terms of the intensity of the sensation. This was followed immediately by a characterization 'heavy' in vocal-motor terms. Nothing was focally present to consciousness from this point until about half way down the down stroke of the empty hand. Then a motor image of the first weight was present in the forearm and was referred to the first weight in a spatial, visual manner. As the second weight was grasped, I was not aware of any tactual sensations at all. But just before the grasping of the second weight I was aware that the arm was in a tetanus condition and I was then aware that the arm went up faster. I was not aware that the arm had been in a prepared state until just before the lifting occurred. The judgment was verbalized at once."

10. Series VIII. 3/29/13. *108.* 'Heavier.' "The experimental situation was visualized in the fore-period, but not very clearly. As the first weight was lifted I was aware for an instant only of pressure sensations on the end of my fingers. When the weight was lifted I was aware of sensations from the wrist and from the forearm; and this was increased in intensity, reaching a maximum when the weight was at the top of the stroke. As I returned the first weight to the table I visualized it very clearly. During all of the time that the empty hand was lifted and lowered I was aware of an image of the kinaesthetic sensations of the first weight in the forearm, referred to the

first weight in a visual spatial manner. As I was about to lift the second weight, the image of the kinaesthesis required to lift the first weight continued and had resolved itself into a muscle tetanus. And when the second weight was lifted I was aware of a pulling down on the muscle of the forearm and of the wrist over and above the tetanus condition. There appeared to be a tendency for my arm to pull downward and it required a greater exertion to lift it up. This was followed by pleasant affective toning and the judgment in verbal motor imagery. After the judgment I visualized the second weight toward the right as a solid mass."

11. Series XVII. 6/12/13. *104.* 'Heavier.' "Attention was very highly concentrated. I was not aware of tactual sensations in fingers when the first weight was grasped. I became aware very rapidly of kinaesthetic sensations in the wrist and in the forearm. At first the sensations in the wrist were more clear, while at the top of the lift the sensations in the forearm became more focal. During the lifting and lowering of the empty hand there were present continually a kinaesthetic image of the lifting of the first weight both in wrist and forearm; this became a very clear motor preparation corresponding in intensity to the lifting of the first weight, just before the second weight was grasped. There was then a very clear tendency for the arm to pull down,—that is, a greater intensity of sensations in the forearm over this preparation. This tendency was visualized at once. Attention seemed suddenly attracted to this pulling down situation and the judgment seemed to be right in this attending. By this I mean that the judgment seems to be complete once this situation is attended to, the vocalization coming later and apparently not necessary for the complete formation of the judgment."

12. Series XII. 5/3/13. *92.* 'Equal.' "This is a case of good subjective equality. Both weights appeared to be absolutely light. In the fore-period I had a vague visual image of the first and second weights and the general experimental situation. With the lifting of the first weight I was aware of muscular sensations in the forearm, very unintensive. This was followed immediately by a visualization of the first weight to the left and high from the table. During the raising of the empty hand, faint kinaesthetic images of the first weight appeared intermittently localized in the forearm. The judgment was formed by the way in which the arm went up,—that is, it corresponded exactly to the motor preparation. At the top of the lifting of the second weight a kinaesthetic image of the first weight, referred to it in a visual spatial manner toward the left, came in and this again corresponded exactly to the sensations in the forearm due to the lifting of the second weight. 'Equal' then came in vocal-motor imagery. Two weights were then visualized to the right and left, both high from the table but both the same height from the table."

The Comparing of Visual Extents

13. Series I. 10/1/14. *148.* 'Shorter.' "My first examination of the first line was accompanied by an awareness of eye-strain of movement from left to right, and also an awareness of strains of convergence which were

very focal. The line was judged as absolutely long, due, I believe, to the duration of this strain. There was then a rapid shift of attention to the second line in which the duration of the eye-strain seemed at one instant to be absolutely long; then relatively longer. This first was present merely in rapidly increasing focality of the strain in consciousness with a heightened visual percept. Then a vague visual image of the first line in its proper position and in which the right-hand end was clearest, came into consciousness. Then there was a flash of kinaesthetic imagery of movement across the first line with attention directed to the relatively light intensity of it. At once the attention returned to the right-hand end of the second line with a lingering visual image of the right-hand end of the first line, and this constituted relativity. This was followed by a visual verbal image of 'longer,' with a faint auditory image of it in my own voice. There was then a shift of the line of regard to the first line with a totally different behavior. I was no longer aware of the eye-strain of movement, but simply of the strains of accommodation of getting both extremities of the line fairly foscused simultaneously. There was then a shift of the line of regard to the second line with the same procedure, and suddenly heightened attention to the extremities of the line. These extremities were clearer, and this clearness was identical to being nearer to each other; that it, the line was shorter. The heightened awareness of the extremities with greater clearness means that the line is absolutely short. A visual image of the first line came in in its proper place with each extremity of it extending so far out that the actual ends were not clearly visible. There was heightened attention to the gradual fading of clearness toward the ends. Attention then shifted back to the second line, and the judgment was a relative one in terms of vocal-motor 'shorter.'"

14. Series II. 10/10/14. *152*. 'Longer.' "This time in the fore-period I set up a definite *Aufgabe* in vocal-motor auditory terms, filled out in a series of visual images and actual eye-movements. The *Aufgabe* was this: 'Go at the thing systematically and get it so that you can introspect decently.' That was the syncopated and abbreviated vocal-motor and auditory process, while the visual imagery was of seeing two lines appear, actually seeing them move into the center of the aperture from below, and there were kinaesthetic images of eye-movements back and forth. When the lines appeared, attention was focused upon the left-hand portion of the aperture with intensive strains in the shoulders, back, and a slight tendency to hold the breath,—in other words an intensive and general attention kinaesthesis. Then I rather deliberately fixated the first line at about its middle point, and I was aware of considerable amount of eye-strain, and noted in the visual perception (attention went to the ends of the line) in which neither end of the line appeared very clear. Then as my glance was leaving the line there was a sort of flashy visual image of it, which was accompanied by a slightly heightened tension about the face. I was then aware of kinaesthetic sensations of change in the line of regard to the second line, and I again fixated the center of this line. I am aware of no other antecedent excepting the fixation. The right-hand portion of the line became the clearest part in consciousness.

Attention suddenly shifted focally to that end of the line, and this time I am certain that it came in before I was aware of any additional eye strain. But moving my eyes along the line back and forth after that the eye-strain became focal in the same way, as I approached the right-hand end of that line. Then followed immediately a visual schema in which I was focusing my line of regard upon line two with the right-hand extremity of it the clearest part. Superimposed upon this was a visual image of the first line with the focal part of that extremity which, however, fell about an eighth of an inch short of the second line. This last image I believe was a sort of verification process, the judgment having been formed before my visual image appeared. No verbal process was present until the very end."

15. Series II. 10/10/14. *156*. 'Longer.' "This judgment was very difficult. As the last pair of lines came into the field of vision a general strain and unpleasantness lingered over, due to a hard judgment just before. This involved frowning, slight squinting, and sensations of tenseness about the jaws. My line of regard shifted to a position so that I would perceive the first line. My line of regard shifted very rapidly from left to right over the first and second lines, with an awareness of the kinaesthetic sensations involved. There was then in very rapid vocal-motor auditory imagery: 'I can not see any difference.' The process involved in this was a rapid shift of the line of regard across the first line, with a slight hesitation at the right-hand end, and at this time the attention was directed to the eye-strain. Immediately I attempted to call up an image of the eye-strain at the end of the first line, but I was unable to do so. I was then aware of turning to the second line and of the sensation of going over it rapidly. When I got to the end of this line, attention went at once to the eye and the only thing that attention was focally directed to was that there was a lack of eye-strain. The line of regard was held for a considerable time at the end of the line. Considerable strain developed in the vocal organs with very faint snatches of words that I am unable to repeat, but these meant for me surprise at the presence of no strain in the eye. At this time there was no idea present as to whether either line was absolutely long or short. My line of regard passed over both the first and second lines rapidly several times. And as I did this the awareness of the right-hand end of the second line increased. I was unable to detect any difference in the temporal sequence between the awareness of increased eye-strain as I got to the end of the line and the increased perceptual awareness of the end of the line. Immediately a strain developed in the vocal organs to say 'longer.' But outside of this pure verbal process I was not aware as to whether the judgment was relative or not. Here there was a slight doubt expressed by the line of regard lingering on the end of the line and a slight tendency to frown. Here the behavior changed. There was a change of accommodation to take in the whole of the second line, with just a faint awareness of the intensive strain in the eyes. I turned rapidly to the first line, and here again I was unable to detect any temporal differences in the awareness of two things: First, a slight decrease in the intensity of the strain in the eye; and second, the line coming out very clearly in visual perceptual terms. At once there was a decrease in

the concentration of attention, and the word 'longer' occurred in vocal-motor auditory imagery.'

16. Series I. 10/1/14. *152.* 'Equal. "Very rapid shift of the line of regard over the first line, with marked awareness of eye-strain of two kinds: First, that of accommodation localized in the internal part of the eye; and second, eye-movements localized in the external muscles. At the same time I was aware of seeing the line clearly in all its details. It seemed to be darker and absolutely quite long, in terms of heightened awareness of eye-movement. The feature of the duration of the eye-movement stood out very clearly. This was followed immediately by unpleasantness and a vague vocal-motor image: 'This seems long.' There was a lingering of attention upon this eye-strain. I was aware then of kinaesthesis of change of fixation to the second line; then the eye moved across this line until I got to the right-hand end, when perhaps an eighth of an inch of the line was focused and stood out clearly with the rest of the line present, but in peripheral vision and in the fringe of consciousness. At the instant when I was aware of the right-hand end of line two in clear visual perception there was an immediate tendency for the strains about the head and eyes to relax. This tendency stopped suddenly, however, and strains came in following a gradual clearing up of the perception of the whole line. At this time there was an immediate absolute judgment: 'Short,' in vocal-motor imagery when the eye focused the middle of line two, with, however, most of that line perceived with an equal degree of clearness. For an instant attention seemed to linger upon the position of the ends of line two, and noted the nearness of the extremities to each other. This was the immediate antecedent of a sweep back of the line of regard over the second line. Then the eyes travelled over both the first and second lines again, with an awareness of the kinaesthetic sensations involved in these movements. By now the lines began to move and in this last shift of fixation there was a real comparison of the lines, which came about in this way: I was aware of strains of accommodation so that I could take in the first line as a whole. Attention was very clearly on this eye-strain. At once I turned to the second line with the same process, and again with attention on the eye-strain. As I was looking at the second line, attention shifted for an instant to a kinaesthetic image of the eye-strain involved in the first line, with a vague visual image of the first line in its proper position. This sudden shift of attention was immediately followed by an increase in the general bodily strain, then a tendency to say in vocal-motor fashion: 'Can not see any difference.' But the strains and the unpleasantness were focal. Just as the lines were disappearing I returned to both the first and then the second line and had a visual comparison. I looked at the first line with a visual image of the second in consciousness in its proper place. This was immediately followed by a sudden flash of seeing both the two lines in their proper places, but neither was clear. Immediately the judgment 'equal' came in vocal-motor and visual verbal imagery."

17. Series I. 10/1/14. *150.* 'Equal.' "The main feature was the fact that simply heightened attention upon a strain or a sudden holding up at the

end of a line suffices for a judgment. I mean by that that no verbal process need follow. But it is the mere kinaesthetic tendency to relax. At first I was aware of the kinaesthesis involved in a rapid shift of fixation over the first line with no tendency to stop. The awareness of a similar movement over the second line was then present. When I came to the end of the second line, there was a heightened awareness of eye-strain of the perception of this portion of the line, and an immediate tendency to relax, with pleasantness. I was then aware in kinaesthetic terms of a rapid shift back over the first line and the portion of this line at the left-hand end seemed to come in suddenly, and there was marked attention to the eye-strain at this point, in which slight absolute intensity was noted. The sudden manner of this behavior seemed very pleasant. This was followed by a visual image of the first line as a whole with the left end clearer than the right, and both extremities were near together; this meant an absolute judgment of 'short.' Tendency to relax but this was checked suddenly and turned to a much greater strain in the face, tightening of the jaws, and general tendency to straighten up. The antecedent of this was a faint visual image of the second line in which only the right end was clear. Accompanying this was a faint kinaesthetic image of the eye-strain referred to this portion of the line. This meant that I had already made the judgment 'longer.' Now I apparently accepted the second as the standard line and the first as a comparison. I took it that my judgments conflicted. There were immediately several rapid shifts of fixation over the first and second lines, in which the attention shifted now to the strain of the approaching end of the line, now to the visual awareness of the position of the extremities of the line. The final judgment was a negative one in vocal-motor terms: 'I can not see any difference.'"

18. Series III. 10/22/14. *154.* 'Equal.' "When the lines became stationary I was aware in terms of kinaesthetic sensation, of the same rapid glance from the left to the right. When I got to the end of the first line this time there was no actual stop in the line of regard, but as I got to the end of the line, attention suddenly broadened out so that I perceived the line as a whole. In this there was actual kinaesthetic strain of the eye-muscles. A visual image of line one then appeared as a whole, with also a kinaesthetic image of the strain which I had had just before in regarding it. This strain was actually so intensive and slightly unpleasant that I am almost tempted to say that it was actual innervation, although directed toward a visual image. My line of regard then passed rapidly to line two in which the same procedure occurred. When I got to the end of the line there was a sudden slight shock of surprise expressed in terms of a rapid contraction of muscles about the face, and inhibition of the particular phase of breathing, and a tendency to sit a little more rigidly in my chair. All this meant to me: 'Why doesn't something happen?', although it was not filled out in these vocal-motor terms. It was interpreted immediately afterwards as a surprised state. Line two seemed neither longer nor shorter,—just a negative affair. Then there was an immediate activity consciousness of attending to both lines more nearly at the same time, and leaning forward in my chair. More intensive strains, not only about the eyes but of frowning, squinting and the like, in which the

eye-movements went rapidly back and forth from one line to the other. These movements gradually became shorter in the angle through which the eyes were moving, and finally my line of regard became stationary at a point midway between these two lines. Visual attention during all this time was directed particularly to the outer ends of both lines. I attended, however, not only to the visual perceptions but to the eye-strains of accommodation and also to the strains of eye-movement localized in the external muscles. Then the judgment 'equal' developed, first simply in a heightened awareness in visual perceptual terms of the extremities of the line, neither one of which went out any farther from the center of the focal point of my perception than the other. This was present in this manner: As I attended to the outer region of the line, attention took in the space for a certain distance beyond the line. As it did so attention shifted to the other side. There was at the final stage of this experience a slight visual image of the first line superimposed over the second line and extending out the same distance. Then attention went focally to the end of the line, to which my line of regard was directed more nearly, and the lines seemed to be clearer and the black more intensive. Immediately there were strains in the vocal-motor organs with vocal-motor auditory 'no difference,' and this was followed by the vocal-motor 'equal.' There was pleasant affective toning while the verbal judgment was being made, and relaxation about my trunk and shoulders. Also, at the very last, just before I stopped, when the word 'equal' was present in auditory and syncopated vocal-motor imagery, I had along with this a very peculiar thing. It was a visual percept while the line of regard was still directed toward the right-hand extremity of line two. Above there was a visual image to the left and upward, very intensive and non-focal, which had a light mass at the further end, and was a little darker in the center. This meant a faint awareness of the other line. As far as I am able to say, that visual image came in while my line of regard was fixated on line two, and I can not see that it had any particular significance in the formation of my judgment."

19. Series IV. 11/5/14. *150.* 'Shorter.' "In the fore-period there was a great deal of frowning and squinting of the eyes in an effort to get a good focus on the lines so I could see them clearly. There was continuous strain all the time the drum was revolving until the second pair came into the aperture. As the two lines were appearing my line of regard tended to be fixated at a point about midway between the two lines and about an inch above the place where the lines would fall when the drum was stopped. As the drum stopped I was aware of two things. I was first aware of a very sudden relaxation of the strains of frowning and squinting which had lasted up to this point. The relaxation was not complete, however, but the strains became relatively non-focal. There was also a strain in the interior of the eye which seemed to be steady, constant and fixed, and this persisted. The awareness of this latter strain was followed by a vague visual perceptual awareness of the portion of the card where my line of regard had fallen, and of the left-hand line lying below and somewhat to the left. I did not see this line as a whole; I saw only the right-hand portion of it. I instantly left this portion of the card, however, immediately following a vocal-motor image:

'Oh, I know what that line is.' This latter was very rapid and very fleeting. I think the important feature through all this experience was the rapidity with which my line of regard turned away from the first line and went rapidly to the second line. I saw the second line at once as a whole. That is, fixation was not upon any particular portion which came out focally. My fixation was in the center of the line, but the center was no more clear than the ends of the visual perception. This visual perception never became focal and was very fleeting and rapid. I was immediately aware of a let-up in the strain in the interior of the eye; this let-up of the strain was very clear and seemed to be localized internally in the eye, and seemed to be circular,—that is, a pull or release in a number of directions simultaneously. As I have said, however, I never saw the second line clearly. The verbal statement immediately followed the awareness of muscular release and was present with a great deal of subjective certainty, due partly, I should say, to the clearness of the strain and the clearness and vividness of the actual verbal statement as I gave it. This was followed by an immediate relaxation of attention."

20. Series IV. 12/3/14. *146*. 'Shorter.' "As in former experiences, my line of regard first fell upon the second line when the drum had come to a stop. I was aware of an immediate let-up of strain in the interior of the eye. That was the first thing of which I was aware. Immediately following this, and indeed, perhaps overlapping the first experience somewhat, was the clearing-up of the perception of the line visually, in which the focal thing about the line was the spatial position of the two ends with about an eighth of an inch of space at either end, which I saw clearly in that perception. As far as I could tell, the two ends were seen simultaneously with equal clearness, my fixation being on a spot in the center of the line. I was not aware of a single eye-movement in this experience until the judgment was made, and I corroborated it. Then there was the same kind of corroboration as before,—namely, a turning of the line of regard to line one, with an awareness of strains in the interior of the eye, then a rapid change of fixation to the second line, and an awareness of the let-up in these strains."

21. Series VII. 12/5/14. *156*. 'Longer.' "There was a fixation of line two directly, with an awareness of strain in the internal part of the eye. Immediately on my fixation of the second line I was aware of an increase in the intensity of this strain. Partly overlapping this increase the visual perception of the line cleared up and I noted the spaces at either end. Without a vestige of consciousness of eye-movement or without a bit of change in the point of fixation on the card, I saw the first line in the periphery of the field of vision. This was apparently the immediate antecedent of a shift of the line of regard to line one and a judgment of this line in the reversed order. That is, it seemed shorter than line two. The judgment was verbalized immediately."

22. Series IV. 10/29/14. *156*. 'Longer.' "In the fore-period I was barely aware of any visual imagery of the lines appearing. Just as the lines

were about to appear, suddenly the perception of the moving drum became focal and this was immediately followed by an awareness of kinaesthesis of straightening the shoulders, tension about eyes and face, and in vocal-motor auditory imagery: 'Get prepared.' This was apparently the antecedent for my turning my line of regard toward the right of the aperture. As I was aware of turning my eyes and fixating the right of the aperture, I was also faintly aware of an internal eye-strain developing. As the line became stationary I was aware of two things: My line of regard was fixated about the middle of the second line. There was next in consciousness an awareness of a sudden increase of intensity and also clearness of the internal strain in the eye. The next thing which occurred was a sudden visual fixation in perceptual terms of the line which extended way out. This was followed immediately by a dropping of attention, which occurred, indeed, before my vocalization of the word 'longer.'"

23. Series VI. 12/3/14. *152*. 'Equal.' "When the stimuli became stationary my line of regard was immediately focused upon line two. I hate to describe the thing in negative terms, but at the outset that is what seemed to be present. Just simply a blank in consciousness so far as things which generally occur are concerned. Those matters that occupied consciousness were strains of fixation and apparently an immediate awareness that nothing had happened. This seemed to be expressed in terms of unpleasantness, the visual perception clearing up with no awareness of either ends of the line or the line standing out. There was in visual perception simply a black line with no part more focal than any other. Then a sort of visual schema came into consciousness. There was a flash of a visual image of my eyes as if I were looking into my own eyes from the front. That seemed to indicate or mean that there had been no change in the eye-strain with which I had approached the second line. Then quick as a flash my line of regard turned to line one, which I was aware of in terms of kinaesthetic sensations localized particularly in the external eye muscles. At this time the judgment 'equal' started to be formed in this manner: vocal-motor 'no difference.' My line of regard shifted back to line one and there was no difference in the eye-strain. This was followed by very rapid shifting of eye-movement from one line to the other and back again, in which attention to the internal eye-strain dropped out entirely and the visual perceptual features largely predominated. In these two or three alternations of my line of regard every time it rested on one line I noticed no tendency for my line of regard to linger on the right-hand extremity of the line as it usually does. Then there came in, in vocal-motor auditory imagery: 'Can not see any difference.' Then to interpret the thing, a judgment of absolute equality came in. It consisted in this: Fixation of line of regard in the center of line one, with accommodation so that I can just see both ends with approximately equal clearness. A shift of fixation to the center of line two with the accommodation held, and I perceived both ends again with approximately equal clearness. This seemed to be the content of the final absolute equality judgment which found expression in vocal-motor auditory imagery: 'Those *are* equal.' The absolute equality was a very gradual growth which grew out of the negative judgment that the lines were not different."

The Comparing of Auditory Intensities

24. Series II. 1/28/15. *50.* 'Softer.' "In the fore-period attention was exceedingly focally directed to the region of the apparatus, first in terms of a faint visualization of the apparatus, and of you sitting before it, and of flashy visual images of the pendulum suspended in mid-air. This visual imagery soon gave way to focal consciousness of strain about the face, the eyes and the jaws, and of a visual and tactual awareness of the region of my ears. The muscles in the shoulders, arms, trunk and legs were all very tense. As the stimulus was given, there was an auditory perception of the noise for a very brief instant, which was very clear and focal. This rapidly gave way to a consciousness of a jerk of pretty nearly my whole body, but particularly in the neck, and a jerky strain in the muscles of the throat. This sudden contraction was also accompanied by tensions in the chest of holding the breath. In the interim between the first and second stimuli I was vaguely aware of the region of the apparatus in terms of visual imagery. The features which were focally present to consciousness at this time were vague lingerings of the strains which I described a moment ago. The strain in the throat, however, remained rather intensive. The second stimulus was given and I hardly noted the auditory qualities of it at all. I found immediately upon a rather non-focal perception of the sound itself, a muscular contraction very much the same as I have described before. In the first place, this was absolutely of not very great intensity. This second muscular reaction had barely begun when I tended to visualize the muscles of my arms and face in movement. I simply seemed to see them contract. This visual image was localized in front of me and was a visual schema. With this schema there was present in consciousness also faint auditory imagery, and a slight tendency to contract again as I had to the first stimulus. This was referred to the first stimulus by spatial visual localization toward the left. This schema immediately developed from an awareness of the second contraction, and my awareness of a low degree of absolute intensity consisted in merely a focal attending to the kinaesthetic factor of contraction. There was then a slight intake of breath and a slight opening of the mouth which seemed to constitute a state of surprise and a focal attending to the relaxation of this contracted state as well. The comparison judgment was made in terms of this visual schema."

25. Series II. 2/4/15. *45.* Softer.' 'In the fore-period I found myself getting prepared for the stimulus not only by way of attending to the apparatus direction, but getting my body in a state of preparedness. Attention went partly in visual terms to the region of the apparatus and to the experimenter, and I faintly visualized the apparatus, but the main thing was the direction of my line of regard toward that region. Along with this there was also kinaesthetic and visual attention to my ear region. Slight strains about the face, forehead and twisting of the head to one side, with the left ear toward the apparatus, although my line of regard still seemed to be directed toward it. The first sound was given and the auditory perception of it was never at any time very focal. Immediately, so quickly that attention seemed to shift suddenly from the sound of it, was the muscular reaction which constituted a

squinting of the eyes, slight jerk in the back of the neck, shoulders and lower trunk. Then immediately afterwards a faint auditory image of this first stimulus, which did not have very much significance. I was aware of keeping up a rather intense strained condition and these strains were localized particularly about the eyes, the side of the face, toward the left ear, throat and shoulders. When the second stimulus came there was hardly any focal attention to the auditory perception itself. Immediately relaxation of musculature, particularly the eyes, throat, back and abdomen. Immediately upon this relaxation there was a welling up of pleasant affective toning and a visual schematization of this one tone which was visualized as a thin, light-grayish air current localized toward the right. Immediately the auditory vocal-motor image 'softer' came in, and attention turned from the experiment and I began to introspect."

26. Series IV. 3/11/15. *45*. 'Softer.' "In the fore-period there was a strained condition of the muscles about the throat, brows and chest, which gradually increased to a marked degree of intensity. This was concomitant with a quite clear visual schematic image of the experimental situation in which the apparatus and the experimenter were clearly imaged. Upon the first stimulation the auditory quality never stood out very clearly, although it gradually increased in clearness and intensity. This auditory perception was accompanied by a rather marked motor reaction which included slight tendencies for the eyes to shut tightly for an instant, for the musculature in the throat to contract and an inhibition of breathing. Along with this was a continuation of the strains of the forehead and I immediately found myself focally attending to the auditory stimulus and hanging on to it. This turned to an auditory image which continued practically to the perception of the second stimulus. The principal feature was that I tended immediately to visualize the first stimulus. I saw it stretched out in a sort of visual schema like the tail of a comet, but instead of growing larger it grew smaller from the place where it started. The auditory perception of the second stimulus rose to its maximum degree of clearness and intensity much more rapidly than had the first. Nevertheless it did not last so long. There was not so much tone in it; it was more of a noise relatively, than the first stimulus, but these features I did not notice as being relative at the time. Attention did not go to them. All I was aware of was a sudden finding of myself focally attending to those qualities I have just given, with muscular relaxation in the throat, eyes and chest. But this muscular relaxation was less focal in consciousness than a visual schema which again came in. This was again an image of the comet which I have described a moment ago, localized to the right, and very much shorter than the other had been. There was eye-movement along this schema which came in concomitantly with the general muscular relaxation. When the eyes had reached the further end of my image there was vocal-motor auditory imagery of the word 'softer.' It seemed to me that the focal and important thing in the whole experience was this visual schematization."

27. Series I. 1/21/15. *45*. 'Equal.' "This time there was a perception of the first noise and the same sort of kinaesthetic reaction to it, but this was of less intensity. This motor reaction in chest, back, neck and throat turned into a motor set which was maintained until the perception of the second stimulus. The first thing which occurred on the perception of the second stimulus was a slight jerk in the parts already mentioned, and the judgment came out in these terms. As the jerk was occurring, the musculature of the face, shoulders, and throat was very focal and very keenly attended to. I was not only aware of the kinaesthetic element as such, but also of this kinaesthetic element visualized in front of me. Again as before, as this musculature was in the process of contracting I tended to follow my eye along a straight line away from me. After attending to this schema, attention dropped to a very much lower level. There was not the slightest tendency to vocalize my judgment until I had a visual image of you. Then the word 'equal' came. This muscular reaction brought to the focus in this visual schema was of the same intensity from beginning to end, and I attended to no one portion of it any more than to any other. There was no tendency to attend to the end of the schema. In other words, this was my visualization of the fact that I had perceived in kinaesthetic terms that there was no rise or fall in the intensity of the contraction following the perception of the second sound."

28. Series II. 1/28/15. *60*. 'Equal.' "The perception of the first stimulus was followed by very much the same muscular contraction that I have just given previously. There was a continuation of this contraction and a sort of motor set up to the perception of the second stimulus. The only way in which I can describe this experience is in negative terms. There seemed to be no tendency to relax; neither did the muscular reaction become more vigorous. No change in either direction. Attention went immedately after the perception of the second stimulus to the region of the apparatus; I visualized it. This was followed by a revival of the two noises in auditory imagery and in vocal-motor imagery of singing them; and again no difference became apparent. Then there was a flashy visual image of you, followed by total relaxation. The vocal-motor image of the word 'equal' came in immediately following the vocal-motor and auditory repetitions of the two stimuli. For an instant I thought that the stimuli were absolutely equal. This did not come until I had that auditory vocal-motor imagery. All I can get was the word 'equal' in vocal-motor auditory terms, which came in with a very slight feeling of familiarity which seemed to consist in faint pleasantness and very faint organic sensations of a contracting nature in the region of the diaphragm, and with very focal standing out in auditory form of the qualities of my own voice."

29. Series II. 2/4/15. *65*. 'Louder.' "This time there was nothing of importance in the fore-period beyond the strains with a highly attentive state. Perception of the first stimulus was followed again by the same muscular reaction which I have described before, particularly in the throat, neck and shoulders. A continuation of this muscular strain until the second stimulus

was given. The auditory perception of the second tone stood out. It seemed to be more voluminous and more penetrating. At the same time attention went to a consciousness of an additional motor contraction localized as before. Tendency also to twitch the left side of my face and a bit more of an intensive jerk in the throat. Immediately there was a turn of attention from the problem, accompanied by 'louder' in vocal-motor auditory imagery."

OBSERVER *Fs.*

The Comparing of Lifted Weight Stimuli

30. Series I. 2/25/13. *100.* 'Heavier.' "The muscular image connected with the lifting of the first weight remained over up to the lifting of the second weight. This was localized in the muscles in the back of the hand, arm, and there was also accompanying it, visual imagery of the lifting of both of these. The second stimulus was visualized as about a third larger than the first, and darker as well. The image of the first lifting, which remained to the lifting of the second weight, showed a marked tendency to tail off and was renewed several times by actual motor innervation. That is, I moved my hand several times between the setting down of the first stimulus and the lifting of the second. This, however, was not very focal in consciousness."

31. Series I. 2/25/13. *88.* 'Lighter.' "The judgment was essentially a memory awareness of the energy used in the lifting of the two weights. These two memory images were not simultaneous in consciousness, but follow one after the other. They were then translated into visual imagery in which the first stimulus was visualized as a small and solid weight, the second as larger but not so solid. The muscular memories of the lifting of the first weight persisted and were reinforced from time to time by slight actual motor innervations. Then with the lifting of the second weight it went up higher and faster than my image of the first, and the judgment followed at once."

32. Series III. 3/10/13. *104.* 'Heavier.' "There was no visual imagery connected with this experience. I am unable to recall any memory of the weight from the lifting of the first weight to the lifting of the second weight. But the memory of the effort due to the lifting of the first weight was focal up to the moment when the second weight was grasped. Then sensations connected with the lifting of the second weight became focal and the judgment followed immediately. The muscular effort was localized in the back of the hand, back of the wrist, and the forearm."

33. Series X. 5/5/13. *84.* 'Lighter.' "The first weight was lifted and I was aware of its being absolutely heavy. This was in terms of very intensive muscular sensations in the back of the hand and arm and wrist. This was followed by a vocal-motor 'Hm, easy.' Visual imaginal reference to the second weight. This meant that this was going to be an easy judgment as the second weight could not be heavier than this weight which I had just lifted. A primary image of the kinaesthesis involved in the lifting of the

first weight localized in the hand, wrist and arm, persisted up to the next, but was not so clear as usual. The second weight was lifted in the presence of this image, and I believe I was aware of an actual difference in the rate with which the hand went up. The hand not only went up faster with this second stimulus, but there was also awareness of very slight intensity of kinaesthesis needed to lift the weight. The judgment 'lighter' came without being pre-imaged and there was pleasantness at the end of this experience."

34. Series XIII. 6/21/13. *88.* 'Lighter.' "After the lifting of the first weight, I had a good primary kinaesthetic image localized in the back of the forearm, hand, and especially the wrist; this persisted up to the second weight. This seemed to be particularly of a tendinous sort. The second weight was lifted, and at first I was aware of very little difference. But the sensations connected with the second weight seemed to be a little less intensive, or, in stimulus terms, the weight came up easy. This seems to be a direct awareness of difference from a particular muscular set that hangs over. I seemed to be set for a certain amount of effort. Not directly aware of the muscular set but still in a way I am, as this memory image perisists. If there is a great difference I merely give a verbal expression of it. Apparently I am not aware of the hand-movements of the empty hand between the replacing of the first weight and lifting the second. But the image connected with the lifting of the first weight remains dominant throughout this period. I do not remember any visual accompaniment in this experience; if present it was exceedingly non-focal and I am hardly aware of the verbal judgments, and there is no verbal pre-imaging of the judgment. The differentiation seems to be entirely in the way in which the second weight came up."

35. Series X. 5/5/13. *100.* 'Equal.' "This was a case of good subjective equality. The liftings were approached with very keen attention. The first weight was lifted and I was aware of the sensations involved, particularly in the wrist, back of the hand, and arm, and a good primary muscular image localized in these parts persisted in practically its initial intensity up to the lifting of the second weight. This muscular strain seemed to be duplicated in the lifting of the second weight. In this process there seemed to be nothing more than the sensations connected with the lifting of the second weight coming upon the image of the kinaesthesis involved in the lifting of the first weight. There was immediate release in the tensions of a general bodily sort, and expiration. Then later the word equal' occurred in vocal-motor terms. The down-stroke of replacing the second weight did not function as the judgment was completed before the weight was poised at the highest point in the lift. There was pleasantness, and the judgment was vocalized with great readiness and finality."

36. Series XI. 6/19/13. *96.* 'Equal.' "This time the visual accompaniment of the lifting was present, but not focal. First weight was lifted and the sensations, particularly in the wrist, forearm and hand were perceived; good primary memory image of these remained over to the lifting of the second weight. I was aware of no definite difference. There was

again a lingering of attention upon the second weight, or of a primary image of a kinaesthetic sort connected with the lifting of this weight, and the visual imagery of the lifting of the two weights in immediate succession became very focal. In other words, the non-focal visual imagery became fairly focal and I reviewed the lifting of the two weights in visual imaginal terms. I was unable to distinguish any difference in the rate with which they were lifted. This functioned as an unwillingness to say 'equal.'"

The Comparing of Visual Extents

37. Series I. 9/29/14. *146*. 'Shorter.' "Attention at first went to the left-hand line, the eye moved along in the same fashion as before,—that is, more rapidly in the middle than at the ends. Then there was eye-movement in a single sweep from the left-hand to the right-hand line, and the process of moving across the right-hand line was the same. When the line of regard arrived at the right-hand end of the right-hand line, I suddenly found myself fixating a point an eighth of an inch to the right of this line. There was the slightest sort of a kinaesthetic start which involved instant stopping of the breath at the inhalation phase, and highly concentrated visual awareness of the distance of the fixation-point from the end of the line. Immediately 'less' followed in vocalization, and marked bodily relaxation followed."

38. Series I. 9/29/14. *156*. 'Greater.' "The eyes moved from left to right over the left-hand line, then in a single sweep to the left-hand end of the right-hand line and across this line toward the right. The fixation paused at the very end of the right-hand line and was focused narrowly upon about one-sixteenth of an inch of the right-hand end of this line. With this focusing, which lasted some time, a gradual increasing kinaesthetic tension was involved in the squinting of the eyes and an increasing pressure of the tongue in the roof of the mouth. No affective toning. Then a re-exploration of the left and right-hand lines, which consisted in a mere rapid passing of the center of each line, with more time spent upon the ends. That whole sweep constituted an experience of smallness,—that is, the experience itself was brief. It was smallness in absolute terms. I was then aware in indirect vision of two-thirds of the right-hand line and then the judgment was spoken. As I gave the judgment there was very definite relaxation of bodily tensions."

39. Series I. 9/29/14. *148*. 'Equal.' "This time I was aware of slightly greater than usual concentration in the fore-period, which involved a narrowing of the attention and gradual tightening of the shoulders. I was aware of nothing but a slightly and slowly increasing tension in the rectus muscles and squinting muscles. Unpleasantness increasing gradually until stimuli appeared. Aware of rapid strains of eye-movement over the left-hand and then the right-hand line. There was no tendency to stop anywhere upon the right-hand line, and the period at the close of the sweep was marked by a heightening of the former tensions and a distinct awareness of the region of the heart. There was also the vaguest awareness of a respiratory suspension, stopping where the breathing happened to be at the moment. Great unpleasantness. Afterwards my line of regard swept from right to left, over the

line several times. Still no end region held attention and there was a slight slump of attention and a state of indifference which lasted until the exposure started to move away. This was essentially a state of relaxation. As the stimuli started to move away, the attention kinaesthesis gathered once more and I watched the drum as it started to move. Both lines were perceived and still there was no holding of the attention at any part of either line and I said 'equal.' "

40. Series II. 10/22/14. *144.* 'Shorter.' "I attended to the left-hand line with fixation about the center, then to the right with fixation about the center. Visual attention on the right line as somewhat smaller than the left line. The left-hand line was also present in indirect vision at the same time, or in immediate succession. Back to the right line and this stood out in sheer visual fashion as longer than the left line, to which I attended either at the same time or immediately afterward. Then back to the right line, and the judgment followed."

41. Series II. 10/22/14. *154.* 'Equal.' "Awareness of the lines as wholes throughout, and in no case was I aware of eye-movement along any line. There was a series of eye-movements back and forth between the right and left-hand lines in every case. Then continued for the whole length of the constant exposure and the lines invariably stood out as equal. There was slight respiratory tension which involved somewhat more labored breathing, but no inhibition. Tension about the mouth, and just as the drum started to move I said 'equal.' I should interpret that increasing strain and constant shift simply as an effort to make sure that there was no difference.

42. Series V. 11/12/14. *146.* 'Shorter.' "Very rapid eye-movement in a slightly triangular form, the bottom angle of the triangle being some point below, and the 'perchings' being somewhat toward the middle, with concomitant or very rapidly succeeding visual awareness of the lines. Slightly persistent visual awareness of the last line, which was accompanied by vocal-motor set which tended to take the form from the first moment I can remember of the first sound in my judgment. Just before the word was uttered during the last of this heightened awareness of the right-hand line, there was relaxation of contractions that I did not know had existed before about the chest. This relaxation was pleasant. Then the word was uttered."

43. Series VI. 11/19/14. *156.* 'Longer.' "I was fixating in the fore-period a point below the opening. My eye struck up as soon as I perceived in indirect vision the stimuli had come to a stand-still, attention having been on the aperture all the time. The line of regard swept up to the left-hand line, landing on a point slightly nearer the central part of the whole perception; then swept to right-hand line and landed on a corresponding point. Back for a brief flutter to the left-hand line, and then very brief fixation of the space below. That flutter with which the kinaesthesis of fixating the left line for the second time was marked, seemed to be such as would be produced by a tendency to return to the lower point. There was momentary in-

hibition of that tendency by return of it to the line, and then finally movement below. During this kinaesthesis the perceptions of the two lines flashed out as wholes very rapidly in visual fashion. I was aware of them primarily as the lengths, black lengths to be sure, but the blackness was not prominent so far as I can say. Then setting of the vocal-motor apparatus for the judgment subsequently given. The first pronunciation of the judgment occurred as I was looking at the right-hand line for the first time. It remained in about that form during the flutter and the word was uttered shortly after my glance fell.

44. Series VII. 12/10/14. *154*. 'Longer.' "That was the nearest to being something of an element of accommodation in it that I have ever had. The eye-movements followed their usual course. There was the usual little click of convergence on the left line, and I am very certain about it. In this next I am not so certain. But for the briefest instant there was the vaguest sort of a kinaesthesis localized exclusively in my right eye. It was a little widening of the eyelids; that was in it, any way. Not certain of anything else enough to give it. The visual percepts of the two lines were the prominent things. There was immediate setting of the mouth for the 'gr' part of the word 'greater,' and with the slightest delay, the word was pronounced. That little additional thing, which seemed most likely to be a widening of the lower right region of the right eye came the instant before the visual standing-out of the right line, but of the order here I am not very certain. That did not stand out as being intimately connected in any way with the judgment process, but is no indication that it might not have been at all. But the perceptions of the two lines were the most prominent thing of the judgment for me. This kinaesthesis had no such obvious connection as that did, but it may have been important.

The Comparing of Auditory Intensities

45. Series I. 1/21/15. *60*. 'Louder.' "There was nothing especially of note in the fore-period except closely concentrated attention. The perception of the first sound consisted at first in something that was more thud than tone. The tone-part seemed to persist and become relatively much more prominent in the perception. There was a slight vocal-motor tendency at first for an instant, to hum the lower note. But that was just the least shift in adjustment in the vocal-motor apparatus as if for a low tone, and the main tone itself stood out immediately afterwards, in auditory imagery. This auditory image was prominent in the interval between the tones, but tended very rapidly to tail off. The perception of the second tone may be described in exactly the same way as the first, with the exception that the actual tone quality of the note itself in the later stages of the perception attracted attention almost exclusively. I was practically unaware of the low tone. Immediately afterwards there was a tension in the throat, in the vocal-motor apparatus. Then there was an auditory and vocal-motor image of that second tone, and along with that there was some respiratory tension as if I were singing that tone with an effort. By this time I became aware,—I think it had been present before,—but attention for the first time went to a kind of

visual spatial schema in which the last tone was prominent. This was visualized slightly to the right as a gray splotch, on which attention was mainly directed. At the time the schema came up, attention was strongly on the right-hand splotch. There was then a moment of hesitation in which I was vaguely aware of an increasing tension in the face and throat. I should interpret this as an effort to recall in auditory fashion the first sound. But at any rate, no image of the first sound appeared. Then attention shifted to the right splotch, then suddenly to my throat, and there was a reinstatement of the experience I had had of humming the tonal part of the second stimulus. Tendency in the mouth and tongue to take the form of saying 'equal' almost as if I were humming 'e' to that tone. The processes joined on to one another in that fashion somewhat. There was a moment of response of that experience. Then the note itself became more prominent than the 'e', and I had auditory, vocal-motor image of the word 'heavier.' I immediately said 'heavier' and remarked that I was uncertain."

46. Series I. 1/21/15. *45*. 'Softer.' "The perception of the first note was marked by the initial experience of thud and rather jangling vibrating quality of tone. Awareness of that jangling quality was accompanied by the slight tensions in the side of my face, and a slight squinting of the eyes; also a slight adjustment of the vocal-motor apparatus for humming the main tone. That adjustment appeared a little later after the jangle died away. In the interval between the two tones there was at first a persisting auditory image of the tone of the first stimulus, and also attention to the adjustment of my vocal-motor apparatus. Toward the close of the interval, attention went focally to the kinaesthesis about my eyes and I actually squinted them a little. That was a cringe in anticipation of the next stimulus. There was for an instant the vaguest sort of an image of you, but with your arm held up. But through it all this adjustment of my vocal-motor apparatus I am quite sure was actually present, although as I have said, attention turned away from it. When the next stimulus was sounded, there was again an initial jangle in auditory perceptual terms, and a slight cringe consisted in an increased tension about the eyes. Out of this experience persisted the main tone which for an instant occupied focal attention. Strains in eyes rapidly disappeared, but this occupied attention for only an instant, and immediately I started to hum the main tone of that note in vocal-motor fashion, with the presence of slight auditory imagery of myself humming it. I believe that there was actual adjustment of the apparatus in the vocal-motor experience rather than imagery. In making the adjustment for the second tone, the experience was similar to singing one a little bit higher than the one for which my vocal-motor apparatus was adjusted. In other words, a slight change as if raising the pitch of the note I was humming, occurred. I believe that there was actual innervation of vocal-motor organs, but that this was filled out to a certain extent by kinaesthetic imagery."

47. Series I. 1/21/14. *35*. 'Softer.' "That time there was a distinct ringing or vibrating in my ear with the first stimulus. It was not present in the second, and that was the basis for the judgment. The fore-period was

characterized by very much closer attention. That consisted in the fact that the only thing present was a vague visual image of you with your arm poised as if to drop some weight. There was also a slight kinaesthetic awareness of the region of my ears, with a visual imaginal awareness of these also. At the same time there was a general bodily tension in the upper part of the head, shoulders, throat, arms and chest, but these were not nearly so focal as the visual factors just mentioned. The first sound was perceived as a rather harsh jangle. There was actually a very slight vibrating in my ears, notably in the left ear, in which the auditory aspect was very hard to distinguish from what seems most describable as a kinaesthetic aspect. There was also increase in tension in the upper part of the body simultaneously with the auditory perception of the first sound. I can remember nothing between the sounds except a rather rapid tailing off of the image of the first. I do not know whether it had quite disappeared when the second sound came. In the second sound, the perception may be described as a much more purely auditory perception. I was utterly unaware of this jangle, part auditory and part kinaesthetic experience described before. This time I had the sound of the thud or something a little duller and less toneful, very rapidly merging into something quite toneful. That last perception was followed immediately by the word 'softer,' without any anticipatory imagery."

48. Series II. 2/4/15. *55.* 'Louder.' "In that case the fore-period was indifferent. First tone was marked by focal awareness of tone plus slight kinaesthetic cringe, consisting in squinting the eye, and a little jerk of the face, occurring simultaneously with focal awareness of tone. Primary memory image, auditory, of tone, with slight persistence of kinaesthetic cringe during the intermediate period. In this image I was aware of the tone ringing slightly and beating a little. It stood out with quite a high degree of definiteness, although not intense. I am utterly unable to say whether it was perceptual or imaginal experience. The second tone came and again tonal perception stood out focally for, I should say, the merest instant of the actual sound. The sound had receded in consciousness and there was now in focal attention a sudden quite intensive kinaesthetic jerk, accompanied very definitely and clearly by a visual kinaesthetic experience. This last consisted in a little jerk of both eyes from a primary point of regard, which was vaguely visualized as a grayish splotch, upward and to the right, to a second point which was also visualized so that the two grayish splotches were two inches apart and up to the right. That was the essence of the judgment in this experience. The word 'louder' followed immediately."

49. Series II. 2/4/15. *50.* 'Equal.' "At the time you said 'ready' I was sitting with arms crossed and generally pretty much relaxed, except for tension about the eyes, which were tightly closed, with considerably more intensity of kinaesthesis than would be involved in holding them closed in ordinary fashion. Breathing, I think, was slower. There was slight awareness of the respiratory situation but very slight, and I think the tiniest tension, both non-intensive and non-focal. The most prominent contents of consciousness were the eye-tension and then visual imagery of you holding

one of these pendulums up,—I think with your left hand. That was very vague. As time elapsed after the ready signal, there was a slight increase in the intensity of the eye-kinaesthesis. In the first sound, I was very focally aware of the thud and the sharp tonal aspect of the thing It is not a sound, strictly; there is a pitch to it. I guess the pitch and the quality is what I mean. Immediately after the sound, attention went to a lower tone,—I don't know whether it is a difference tone or not. Attention went to that in terms of a vocal-motor starting of the set to hum the thing. The second sound was attended to in practically the same manner. I think that the vocal-motor set remained thoroughout to the second tone. Immediately after the second tone there was hesitation in which I was aware primarily of an immediate memory image of that thuddy, tonal thing. It was fully as clear as the percept had been. Sudden change in attention focus then, also; a lingering, more tonal thing that I have reported before; awareness of that in auditory perception and in a slight vocal-motor setting. Awareness of that auditory perception and vocal-motor setting was followed immediately by the word 'equal'."

The Comparing of Visual Brightnesses

50. Series II. 5/6/15. *7*. 'Darker.' "Fore-period utterly indifferent. Not an exceedingly narrow attention. Fixation below the aperture and focal point of attention the aperture with the moving situation behind it. Very vaguely aware of the rest of the room. When the pair of stimuli began to come on the field,—a fact of which I was aware in slightly indirect vision, perceptual terms,—just as soon as I became aware of it there was an eye-movement upward, present to consciousness in terms of change of visual field. I can remember no kinaesthesis at all. Point of fixation described in a line which I might describe as tracing the outline of an isosceles triangle, with a very short base, upside down. Passing up from below it landed on the white between the cards rather near the one on the left. Just the least flutter across to the right, maybe over an area three-quarters of an inch. Then down again. During the instant when it was on the grays I was aware in exceedingly rapid succession of the general central regions of the two grays,—first one on the left, then to the right. The one on the right gained a slightly higher degree of attention and definiteness. Its quality stood out a little more focally, I should say, than the previous one had. The judgment was given with hardly an instant's intermission. I was not aware of any throat tension or anything like that. Just the vocal-motor initiating of the word 'darker.'"

51. Series III. 5/13/15. *6*. 'Darker.' "All there was to that experience was a movement upward of fixation, from the fore-period, which was below the stimulus, the upward movement ending in a point very slightly to the right of the left-hand stimulus on the white part, sliding across toward the right for something less than an inch, and then down. In the course of that the two stimuli,—first the left and then the right-hand,—stood out in rapid succession, the right one being a little clearer. In both cases I was aware of the quality of the stimulus, the gray of it and very marginally aware of

the shape of it. The quality of the second stimulus stood out a little more focally and persistently. I can remember nothing between that and the verbalizing of the judgment. No throat consciousness preceding that at all. Nor was there afterwards any tendency to return to the stimulus, to re-examine it. I can remember no strains or tensions or effective toning at any time in the process. I am not sure but what there was a slight kinaesthesis during the upward and downward sweeps or shifts of focus. I can remember none during the sweep across. But the kinaesthesis was very marginal as compared with the actual visual percept which accompanied it,—the change in the field of clear vision."

52. Series III. 5/13/15. *1*. 'Lighter.' "The fixation was in the usual place during the fore-period, that is, about four inches below the aperture. When I became aware in indirect vision that the stimuli had appeared, there was an eye-movement upward. Kinaesthesis very marginal. The fixation landed at a point slightly to the right of the left-hand stimulus and passed upward and toward the right. The highest point that I can remember its reaching was about the level of the upper part of the two stimuli very near the upper left-hand corner of the right-hand stimulus. During that sweep the two stimuli stood out in very rapid succession,—much more rapid than the last time; first the one on the left and then one on the right. I was only aware of the quality of the gray about the central third or half of the two stimuli. The form was very marginal. The right-hand stimulus was decidedly more focal and that moment of focality seemed to be the most important part of the whole experience. Nothing after that except the verbalizing of the judgment. I can remember nothing about my return of fixation below. Even the memory of the verbalizing of the judgment is rather faint. It was not attended to as was the quality of the right-hand stimulus. The verbalization came immediately after the standing-out of the right-hand stimulus. That remained in consciousness a little longer than that of the left-hand stimulus."

Observer *O.*

The Comparing of Visual Extents

53. Series I. 10/10/14. *144*. 'Shorter.' "The line of regard was on the right-hand stimulus and there was a movement of the head and eyes from right to left over this line and back again. Then a very rapid shift of fixation to the right-hand end of the left-hand line, and eye moved over this line from right to left. And near the left end of this line there was a sort of muscular hitch in the eyes. At once vocal-motor auditory image 'This is longer.' Rapid eye-movement back to the right-hand line and visual line of regard passed from left to right over this and back again. Then movement of head to the left-hand line, and slow movement from right to left over this. As I neared the end of the line the movement which had been of a tense sort became more free as if I were sliding off the line. This meant to me: This line is so much longer than the other. Then vocal-motor imagery 'this is shorter,' with fixation returning to the right line. This was followed immediately by relaxation and pleasantness."

54. Series II. 10/17/14. *156*. 'Longer.' "The line of regard was first on the right-hand line as the lines came into the aperture. I was aware in kinaesthetic terms of slow eye-movement from right to left and back to the right. Then this was repeated much more rapidly than before. Aware in kinaesthetic terms of rapid movement to the right-hand end of the left line and then rapid eye-movement over this line. My fixation went out beyond the end of the line. A white spot at the left-hand end of the left line was clearly focused, and that meant that the line was so much shorter than the right line. Inhibition of breathing and upward movement of the diaphragm. Eyes passed quickly over the right and then the left line, and I had the same experience of the eye going beyond the left line. General relaxation and kinaesthesis of smiling, pleasant affective toning and vocal-motor auditory 'longer.'"

55. Series II. 10/17/14. *146*. 'Equal.' "In the fore-period there was fixation where the right-hand end of the right-hand line would appear. As the stimuli became stationary in the aperture I was aware in kinaesthetic terms of eye-movement to the left over the right-hand line. Then rapid head-movement to the right-hand end of the left-hand line, and eye-movement across it. The eye-movements stopped exactly at the end of the line. Unpleasantness and general strains with an increased concentration of attention. Very rapid head-movement to the right and then eye-movement over the right-hand line, and then the left-hand line. Same experience of line of regard stopping exactly at the end of the line. This was followed by auditory vocal-motor image: 'They are about even, I think.' Then eye-movement to the right-hand line, and eye-movement across it several times. Then movement of the head to the left-hand line and rapid eye-movement over it several times. Severe strains in the forehead by this time, and almost complete inhibition of breathing. Then vocal-motor auditory image 'about equal.' This, however, was vocalized with unpleasantness."

56. Series I. 10/10/14. *156*. 'Longer.' "When the lines came into the aperture my line of regard was on the left-hand end of the right-hand line. Movement from right to left over this line and back again, of which I was aware in terms of muscular sensations from the external eye-muscles. Then rapid head-movement to the left hand line and slow eye-movement along this. The movement continued beyond the line so that I was now fixating the white space slightly to the left-hand side of this line. This meant that the left-hand line was shorter. Immediate vocal-motor auditory imagery: 'The other line is rather longer.' This was followed by general relaxation and vocalization of the judgment."

57. Series III. 11/7/14. *156*. 'Longer.' "Vocal-motor auditory *Aufgabe:* 'Practice on the first a number of times and then just glance at the second.' In the fore-period fixation where the right-hand end of the right-hand line would appear. As the lines became stationary in the aperture I moved very slowly from right to left over the right-hand line, and, as I reached the end with attention on the strains in the external eye-muscles, I

saw the left-hand line in indirect vision. Then there was immediately a vocal-motor auditory image: 'No, don't mind it; wait.' I retained my fixation upon the left-hand end of the right-hand line. Then there was slight pleasantness; eye-movement from right to left and left to right over the right-hand line four or five times. Then vocal-motor auditory image: 'Don't wait too long.' This was apparently the immediate antecedent of head-movement to the left-hand line. Then vocal-motor auditory image: 'Now go slowly.' There seemed to be, however, a kinaesthetic sensation of the eyes going very rapidly toward the left, and it seemed to drag my actual line of regard after it. This movement went a considerable ways beyond the left-hand end of the left-hand line so that the line of regard was fixated upon the white space to the left of this line. Immediately vocal-motor image of the word 'longer,' and I looked away at once with general bodily relaxation."

58. Series III. 11/7/14. *152.* 'Equal.' "My line of regard was to the right-hand side of the aperture before the lines appeared. When the stimulus came in I was aware in kinaesthetic terms of moving the head slightly forward, with fixation on the right-hand end of the right-hand line. Aware in kinaesthetic terms of eye-movements to the left and then to the right over the right-hand line very slowly, and then back again toward the left. I was aware very keenly of the tension in the external muscles of the eye as the fixation was upon the left-hand end of the right-hand line. I was then aware of head-movement so that my fixation was on the right-hand end of the left-hand line; and then eye-movement toward the left across this line. This movement stopped when fixation was exactly at the end of the line. The left-hand end of the left-hand line stood out very clearly in visual perceptual terms. I was then aware of very rapidly increasing strains in neck, chest and brow, and of accelerated breathing. Then very syncopated vocal-motor auditory imagery: 'I wonder if these are equal; measure them again.' Head moved to right-hand line and there was eye-movement over it several times, each time with a pause at the left-hand end of the right line with very keen awareness of the strain in the eye-muscles at this point. Then head-movement to the left-hand line and eye-movement from left to right across this, the eye-movement stopping so that fixation was again at the end of the line. Vocal-motor auditory 'seems about equal.' Then rapidly developing unpleasantness and vocal-motor and auditory imagery: 'I can't tell, anyway.' Then verbalization of the judgment, and relaxation."

The Comparing of Auditory Intensities

59. Series I. 1/16/14. *40.* 'Equal.' "After the 'ready' signal I gave very concentrated attention to the problem, and when the first stimulus came there was very rapid and clear perception of it, which was followed immediately by a vocal-motor image of myself singing a sound of the same intensity. This vocal-motor set remained with the tongue in the upper part of the mouth and also with innervation of the head forward. Auditory image of the first sound also held over in consciousness, and this was more of my own voice intoning the same sound than of the actual sound itself. When the second came there

was tendency to intone this sound, and the tongue still remained in this fixed position in the mouth. There was also a continuation of this sound in auditory imagery, and both this and the motor set were apparently equalized, so at once I gave the judgment 'equal.'"

60. Series I. 1/16/14. *60.* 'Louder.' "The first stimulus was perceived in auditory fashion and there was accompanying this a kinaesthesis in the neck and shoulders and moving the head and eyes downward. This was followed by vocal-motor auditory image of the word 'light.' Auditory image of the first sound remained in consciousness up to the second stimulus, and the second sound broke in upon it. Immediately following this auditory perception of the second sound, there was a kinaesthesis somewhere in the abdomen and awareness of strains here, and increase of strains in the neck and shoulders. This was followed by the vocal-motor auditory image of the word 'heavier,' and I gave the judgment."

61. Series II. 1/30/15. *35.* 'Softer.' "When the first sound was given there was an immediate vocal-motor set for intoning a sound of the same intensity and pitch as that of the actual stimulation. This was apparently concomitant, at least very shortly after the perception of the stimulus in auditory terms. This motor set in the vocal apparatus was held over up to the second stimulation and there was also present an auditory image of the first stimulus. When the second stimulus was given immediately following the auditory perception of it there was at once, and this was in focal consciousness, a relaxation of the tensions of the throat, neck and body, which appeared to be an adjustment to this stimulus, and the judgment was given at once."

62. Series II. 1/30/15. *60.* 'Equal.' "The first stimulus was presented in auditory fashion and immediately there was a vocal-motor setting for singing this note, and also vocal-motor auditory image 'loud one.' An auditory image of the sound also held over to the second stimulus quite definitely and intensively, but was less focal than the vocal-motor set for singing this sound. Then the second stimulus was given and it affected the auditory apparatus in no different way than the present auditory primary image of the first stimulus, except that the tone seemed to be more filled out and less thin. Also the intensity of the new sound did not give rise to any different setting of the motor apparatus. There was neither relaxation nor increased tension. The judgment was given at once."

63. Series II. 1/30/15. *65.* 'Louder.' "The auditory perception of the first sound was followed by a vocal-motor set and a slight leaning forward of the head, and awareness of tensions in the neck. A primary auditory image of the first sound also continued up to the second stimulation, but seemed to be less focal than the vocal-motor set for singing this sound. Then the second stimulus came, and after its auditory perception, which was very rapid and very clear, there was pushing back of the head and increase in the tensions in the vocal-motor set, and also kinaesthesis as if the ear-drum were widening out. Awareness of this was followed by vocal-motor auditory imagery of the word 'louder'; then the word 'louder' was vocalized."

64. Series IV. 3/20/15. *45.* 'Softer.' "In the fore-period attention to the general apparatus region. First stimulus given and was perceived very rapidly in auditory fashion, and at once there was vocal-motor set as if to make a sound of that intensity. This was retained up to the second stimulus, as well as a primary image of the first sound. There were also strains in the eyes, neck, forehead and back. Slight inhibition of breathing. Second seemed to set off an almost total relaxation, both in the vocal-motor set and also in the tightness with which I had my eyes closed. Also a very deep exhalation. The auditory sensation of the second stimulus died gradually out of consciousness, and for a very brief period there was complete relaxation before my vocalization of the judgment."

The Comparing of Visual Brightnesses

65. Series I. 4/24/15. *1.* 'Lighter.' "Fixation of the left-hand side of the aperture in the fore-period. As the pair came into view a focal fixation of the left-hand stimulus while the right-hand stimulus was present in peripheral vision and it appeared to be very light. This peripheral perception was apparently the immediate antecedent of a change of the line of fixation to the right-hand stimulus and a clear perception of it as it stood out again as very light. At once vocal-motor auditory 'light' and change of fixation to the left-hand stimulus and a rapid change back to the right-hand stimulus and a vocalization of the judgment. There was also great pleasantness and relaxed condition of the usual strains of tension about the eyes, forehead, face and neck immediately following my first perception of the right-hand stimulus."

66. Series II. 5/1/15. *6.* 'Darker.' "When the stimuli came into view I was fixating the left-hand stimulus but saw the right-hand stimulus in indirect vision. This was apparently an immediate antecedent for a rapid shift of attention to the right-hand stimulus, and a clear visual perception of it, which was followed immediately by the auditory vocal-motor images of the words 'not light.' Then complete shift of fixation and total focality of the left-hand stimulus followed for an instant a change of fixation back to the right-hand stimulus. With this change to the right-hand stimulus there seemed to be reflexly a wider opening of the eyes which I was aware of in kinaesthetic terms and a vocal-motor auditory image of the word 'black.' Then slight pleasantness, slight kinaesthesis of smiling, release of strains of attention, slight exhalation and vocalization of the judgment."

67. Series III. 5/8/15. *3.* 'Lighter.' "Fixation on the left-hand stimulus in the fore-period, and as the drum started to revolve there was already a kinaesthetic tendency of the eyes to move to the right. Just as the grays came into view the right-hand stimulus became very focal and it was clearly perceived as a light gray. And then reflexly the vocal-motor set to give the first sound of the word 'lighter.' Very rapid shift of attention and fixation to the left-hand stimulus upon the perception of this. The 'l' set was completed into the vocal-motor image of the word 'lighter.' This was followed by relaxation and the vocalization of the judgment."

68. Series IV. 5/22/15. *2.* 'Lighter.' "This procedure was exceedingly mechanized. In the fore-period while waiting for the stimuli to come to view, attention and fixation were on the place where the right stimulus would come in. As soon as the pair came into view the right stimulus was perceived and perceived as a light gray. Immediately vocal-motor image of the word 'light,' and then a very nonfocal perception of the left-hand gray during a steadily increasing degree of relaxation and vocalization of the judgment."

69. Series IV. 5/22/15. *7.* 'Darker.' "Fixation was on the position of the right-hand stimulus in the fore-period. When the pair came into view the right-hand stimulus was perceived and it stood out as very dark and was followed immediately by the vocal-motor image of the word 'darker.' Then rapid shift of attention to the left-hand stimulus, which was perceived in visual terms and followed immediately by vocal-motor auditory image of the word 'yes.' Immediate relaxation and vocalization of the judgment, with great pleasantness."

70. Series IV. 5/22/15. *4.* 'Equal.' "As the pair came into view attention and fixation were on the right-hand stimulus, which was perceived clearly in visual perceptual fashion. There was at once an inhibition of breathing and slight vocal-motor and auditory image of 'er.' Slight kinaesthesis of moving the head forward and the development of strains in the neck. Rapid shift of fixation to the left-hand stimulus, and a perception of it for a considerable time. Then rapid shift of fixation to the right-hand stimulus and perception of it for a moment, followed by vocal-motor auditory imagery of the word 'equal,' with a questioning inflection. Then a re-fixation and perception of the left-hand stimulus for a considerable time, followed by vocal-motor auditory image of the word 'yes' in a hesitating manner. Then a return to the right-hand stimulus which was perceived very rapidly and rapid vocalization of the word 'equal.' Attention was very highly concentrated on the stimuli throughout all this procedure, and relaxation occurred only after the final judgment."

Observer *S.*

The Comparing of Visual Extents

71. Series I. 2/19/14. *156.* 'Longer.' "When the lines appeared in the aperture I fixated first the left-hand and then the right-hand line. Immediately after my fixation of the right-hand line, I had a visual image of it with a short perpendicular line drawn through it toward the right end. I then had a manual-motor image of compassing the left end of the right-hand line with thumb and forefinger, and checking off the distance between the left-hand end and this perpendicular line. This was followed by a motor image of compassing the left-hand line with thumb and forefinger, and checking off the entire length of this line. The distance between thumb and forefinger remained the same, and were placed now upon the left-hand portion of the right-hand line, with the index finger retracing the perpendicular. Then aware of tracing the right-hand end of the right-hand line, which

was left over, and this was followed by vocal-motor image of the word 'longer.'"

72. Series II. 10/9/14. *152.* 'Shorter.' "In the fore-period I was aware of general tension of adjustment to the problem. The left-hand line was fixated and I was aware of eye-strains which came from a movement of the eyes from left to right, as I fixated a point directly opposite the left end of the line. I was then aware of movement of the head to the right, and fixation of left-hand end of the right-hand line, and an eye-movement to the right across this line. This was followed by the vocal-motor image: 'I don't believe that strain is so great.' I then fixated the left end of the left-hand line and repeated the operation, and the same with the right-hand line. This alternation of movements across the line was repeated two or three times until the drum began to move. The perception of this was followed by a vocalization of 'shorter.'"

73. Series III. 10/30/14. *150.* 'Shorter.' "This judgment was the most automatic and the least clear of any I have had; that is, it was exceedingly short in duration and the elements were not clear. I was aware of looking at both lines as they came into view from a fixation-point midway between them. This was immediately followed by a localization of strain in the left side of the body, and particularly in the left arm. This was followed by vocal-motor image: 'Left is longer.' Then I repeated the process of judgment, fixating again the point between the two lines; again aware of strains. This was followed by general relaxation. I am pretty sure there was eye-movement from the central fixation, but it was so rapid that I can not describe it."

74. Series IV. 11/20/14. *140.* 'Shorter.' "When the lines came into view I found that I was attending to a visual perception of the right-hand line. This was perceived at once as short, and very black. This was followed by the vocal-motor image: 'That line was shorter.' Then I proceeded to verify this judgment and this consisted in perception of the left-hand line and the right-hand line at the same instant, with a fixation between them. This was followed by a rise in clearness of the shortness and blackness of the right-hand line. This was followed immediately by pleasantness and general bodily relaxation and vocal-motor image: 'That was right.' I can not tell how the shortness of the right-hand line was present in the first perception. This perception is apparently an immediate thing. Seemed to be just an immediate awareness of that line."

75. Series VII. 12/11/14. *154.* 'Longer.' "When the lines came into view I was aware of fixating the right-hand line. Perception of that line was partly visual and partly muscular strain in the eyes. Seemed to be strain of divergence. I was not aware of eye-movements across this line. On the visual side I was aware of the apparent thinness of the line. This was followed by the judgment in vocal-motor terms: 'It's longer.' Then I looked at the left-hand line and I was aware of the shortness and blackness of this line, and the outline seemed less clear. That is, it seemed to be

covered by a halo. Then general muscular relaxation, pleasantness, and vocal-motor 'that's right.' I was also aware of a muscular set during this procedure, from the preceding right-hand line; that is, the right line of the preceding pair. After that passed this was carried over all the way from the preceding pair to the next. This set was localized in the eyes, principally, but also muscular tensions in the arms and the muscles of the neck."

76. Series VII. 12/11/14. *146.* 'Shorter.' "This time the perception of the right-hand line of the previous pair was very clear. Feeling of muscular strain in the eyes, localized principally in the internal eye-muscles, and of moving the eyes from end to end of this line. Then I was aware of a visual image of the right-hand line of the next pair, which was immediately below this line and was shorter. This was apparently the immediate antecedent of the vocal-motor image: 'The next line will be shorter.' Then the pair upon which I was to introspect came into the aperture and I at once fixated the right-hand line and was aware at once of the shortness and the blackness of it. This was followed by general relaxation and vocal-motor 'that's right.' Then there was a vocal-motor image 'I will see.' Increase of tension and turning of fixation to the left-hand line. Very short perception of the left-hand line, and in this perception its narrowness and clear-cut edges seemed to stand out. This was followed by pleasantness and relaxation, and vocal-motor 'that's right.'"

77. Series I. 10/2/14. *148.* 'Shorter.' "The fore-period here consisted of eye-strains and a general feeling of excitement which I am unable to analyze. I fixated the left-hand line and then the right-hand line. As I fixated the right line I had a visual image of the left-hand line superimposed upon it, with the end of the right-hand line extending beyond the image. This image of the first line might, perhaps, be called an after-image rather than a real image, because it was very gray instead of black. I was unable to tell whether it was a real positive after-image or a vague visual image. This was followed by the verbal judgment 'shorter' with continued fixation upon the right-hand line, with the image of the left-hand line dropping down immediately."

78. Series I. 10/2/14. *150.* 'Equal.' "There was a general tension and strains in the fore-period, with fixation on the aperture. When the lines appeared I first fixated the left-hand line, and with this fixation continuing I had a manual-motor image of compassing the length of this line with thumb and index finger. Attention was directed to muscular strain in the hand rather than to the visual components of my consciousness; attention and fixation then turned to right-hand line, and I had again a motor image of compassing this line with thumb and forefinger, again with attention to strain in the hand. This process was repeated on both lines two or three times, with continued fixation of the lines. This was followed by a vocal-motor image: 'Can't decide; they are the same.'"

The Comparing of Auditory Intensities

79. Series I. 1/22/15. *50.* 'Louder.' "When you gave the 'ready' signal, I had auditory images of the sound of the pendulum hitting the block, and I was also aware of a motor tension of adjustment and a turning of the right ear toward the instrument. This was followed by a reversal of position so that when the first sound was struck I was facing directly toward the instrument. I had then a visual image of you lifting one of the hammers, and I fixated the block in this visual image. I was aware of motor strains, mostly in the neck and eyes, with occasionally a visual image of seeing the hammer drop. This was concomitant with the tightening of the muscles that controlled respiration, and inhibition of breathing; and then the auditory image of the sound which was concomitant with an imaged motor jerk all over my body. Then the first sound was given and the auditory perception of it seemed to be followed immediately by a slight jerk or muscular contraction localized principally in the muscles of the neck, and apparently in the internal muscles of the ear. This motor adjustment was held over between the first and second stimuli, and during this interval an auditory image of the first stimulus was also reinstated two or three times. The muscular set in neck and ear, however, seemed to be maintained constantly and with constant intensity throughout this period. When the second stimulus came I was aware of an increase of muscular strain, apparently in purely kinaesthetic terms. Immediately there was present a vocal-motor image 'the second is stronger.' There not only seemed to be an increase in intensity immediately following the second stimulus, but also a larger musculature seemed to be involved in terms of a greater extent of localization. Just as I made the judgment I was aware of visualizing this entire situation in terms of a vague visual schema of the block and hammer, and of myself in an exceedingly strained position."

80. Series I. 1/22/15. *45.* 'Equal.' "In the fore-period, I was aware of intense strains and very concentrated attention, the strains being those of fixation in the general apparatus region. I was then aware of the auditory perception of the first stimulus, but I was not aware of a jerk of the body backwards at all, following this. I was simply aware of a general strain which was connected with the fixation of the block, and the general contraction of the shoulders, neck and eyes. This remained over to the second stimulus. This second stimulus was perceived in auditory fashion, and again without the muscular jerk that I have described before. I immediately had an auditory image of the first stimulus, followed very rapidly by an auditory image of the second stimulus. And this time I had the motor adjustment to both. I was unable to find any difference in either the motor adjustment or the intensity of the auditory image. Finally, after a considerable time, the word 'equal' occurred in vocal-motor auditory imagery."

81. Series II. 1/29/15. *45.* 'Equal.' "In the fore-period, I had a visual image of the apparatus in which I saw the hammers fall, with an auditory image of them striking, and kinaesthesis of jerks backwards. The first stimulus was perceived in auditory fashion, and I was aware of muscular

tension about the eyes, neck and shoulders; I was then aware of this tension persisting definitely up to the second stimulus. When the second stimulus struck it was perceived in auditory fashion, but attention turned very rapidly to the motor set, and I was aware of this same tension persisting about the eyes, neck and muscles of the shoulders. This was all of which I was aware. I then reproduced the two stimulations in auditory imagery, with muscular reactions, and when I got through I was simply aware of this muscular tension. This was followed by reinstatement of the auditory images, and the muscular reactions two or three times, with attention simply to the continuance of the muscular reaction, without change. This was followed by the vocal-motor image: 'Well, you had better judge,' which was followed by general strain throughout the body, and a visual awareness of the experimenter. I then had a kinaesthetic image of pushing the apparatus away and a vocal-motor image: 'I can't do it.' The characteristic thing here was that there was nothing there; that is, that after the second stimulus I simply retained the same muscular set. More awareness of muscular tension with absence of ideational elements. This experience was exceedingly unpleasant. I find that the louder judgments are very much easier than the softer ones, as an increase in the musculature seems to be more readily perceived than the relaxation of the musculature."

Observer C.

The Comparing of Visual Extents

82. Series I. 10/14/14. *154*. 'Longer.' "This time the adjustment to the problem was not so active and I did not approach it in nearly so strained or concentrated a degree of attention. When the lines came into view, eye-movements from left to right over the left-hand line. Considerable eye-strain. Fixation then turned to the right-hand line, and I was aware of muscular movements across this line, with an increase in the strain of the eye-movements. Before the eye-movements had reached the right-hand end of the right-hand line there was bodily relaxation, vocal-motor auditory image: 'This one is longer'; and then I finished out the rest of the line in eye-movements."

83. Series I. 10/14/14. *146*. 'Shorter.' "When the lines came into view there was fixation of the left line with considerable strain for a considerable time. Then eye moved across this line from left to right. Change of fixation then to left-hand end of the right-hand line, and movement across it toward the right. I went all the way across the right-hand line and reached the end of the line before the amount of strain in the eye was completed. That is, I reached the end of the line before the strain of going across the left-hand line had been approximated. I then squinted my eyes and saw both ends of the right-hand line at the same time. This squinting was carried over in a motor set to the left-hand line, and before I had a perception of the both ends of the line simultaneously I was aware of a widening out of the eyes and increase in strain. Vocal-motor auditory image 'shorter,' with general bodily relaxation, but particularly in the eyes."

84. Series II. 10/21/14. *148*. 'Shorter.' "Very concentrated attention to the aperture in the fore-period. I anticipated by carrying over a motor adjustment from the pair before. Fixation of first the left and then the right-hand line, and I was not aware of an increased strain in the eyes with fixation of either of these lines, nor by focusing between the two was I able to see which was longer. Attention became now more passive and less strained, and I began all over again. I was aware of eye-movements across the left-hand line and then across the right-hand line, without any effort to form a judgment. A vocal-motor auditory *Aufgabe* was now present to wait until the lines got to the top of the aperture. I then fixated the left-hand line as a whole, and then the right-hand line as a whole, with attention to the strain in the adjustment of the eye. This strain is localized in the interior of the eye, apparently in the lens, cornea, and the like. At least it seems to be in the middle of the eye. After my fixation of the left-hand line the strain carried over and I fixated the right-hand line, and I was aware of a slight relaxation of this strain. Then I reflexly gave the judgment 'shorter.'"

85. Series II. 10/21/14. *144*. 'Equal.' "The strain in the interior of the eye was carried over from the pair of lines before. I perceived the left-hand line and then the right-hand line. Then fixation fluctuated from one to the other. On neither line did the strain let up, so that I could not make any choice. Then the vocal-motor *Aufgabe* was present: 'Wait until the lines are both at the top and get them both at once while looking between.' When the lines were in this position I tried this and for a moment got both at once, but I could not tell any difference, and the strain for each seemed to be the same. Then this developed into positive subjective equality."

86. Series III. 1/14/14. *150*. 'Shorter.' "General attention to the aperture in the fore-period. When the lines came into view, the left-hand line was fixated for a long time with an awareness of eye-strains in focal consciousness, and also an awareness that the eyes moved through a certain angle, which was present in motor terms. I then turned to the right-hand line and moved from left to right through the same angle as before, and at the end of this movement I was fixating the white card a short distance beyond the right-hand end of the right-hand line. Almost concomitantly with this there was quick organic kinaesthetic reaction which I am unable to describe, and which was followed by general bodily relaxation and the vocal-motor image 'shorter.'"

87. Series III. 1/14/14. *154*. 'Longer.' "When the lines came into view I very rapidly noted the eye-adjustment for perceiving the left-hand line. This was not a movement across the line, but I perceived the entire line at one time; and the adjustment of one of accommodation, apparently localized in the interior of the eye. This adjustment was carried over to the right-hand line, and there seemed to be an added increment of adjustment. There was an increase of strains in the interior of the eye, in order to get both ends of the right-hand line in consciousness simultaneously. As soon as the eye had

gotten this adjustment for the right-hand line, with an awareness of the increase of strains of accommodation, there was then general relaxation, and vocal-motor 'longer.'"

88. Series VI. 12/11/14. *156.* 'Longer.' "This adjustment was very rapid and of a very reflex sort. I focused the left-hand line with a single glance of the eye, and was aware of the strains of accommodation carrying over while my fixation changed to the right-hand line. This was focused in the middle with this same adjustment. And then I was aware of a spreading-out of the adjustment with increased strain until the ends of the right-hand line were clearly perceived at once with the auditory vocal-motor image of the word 'longer.'"

The Comparing of Auditory Intensities

89. Series I. 1/22/15. *35.* 'Softer.' "In the fore-period, attention to the general apparatus region and awareness of muscular strains, particularly in the face and across the brows as of frowning; and of auditory images of the sound which were localized toward the left. The first stimulus was perceived and tailed off very slowly indeed. There was an auditory image of the first stimulus present all the while up to the second stimulation. I was unable to tell when the perception ceased and this auditory image began. This auditory image of the first stimulus, which was maintained up to the second stimulus, seemed to remain with the same intensity and the same degree of clearness. The second stimulus was perceived very quickly and was very unintensive, as compared with the image of the first stimulus which had been in consciousness just before. There was then vocal-motor auditory 'lighter' and relaxation."

90. Series I. 1/22/15. *40.* 'Louder.' "Again a slight attentional preparedness for the first stimulation, which consisted in attention to the general apparatus region and slight muscular tensions in the face and brow, and also auditory images of the sound in anticipationn. First stimulus was given, and it was clearly perceived and seemed to last for a considerable time. Then passed out of consciousness, but between the first and second stimulation there were twice present auditory images of the first stimulus. As this image of the first stimulus became very focal the second stimulus was given. The second stimulus was perceived very rapidly and was of short duration and exceedingly intensive, as compared with the auditory image of the first stimulus which had been present just before. Then the auditory image of the first stimulus came in again with visual-spatial localization toward the left. Simultaneously with this there was general bodily relaxation and I reflexly vocalized 'louder.'"

91. Series II. 2/5/15. *50.* 'Equal.' "In the fore-period there was general bodily attitude of frowning, kinaesthesis of contraction of the muscles of the face, and auditory images of the pendulum striking, which were very unclear; also very vague visual images of the apparatus. First stimulus was given and very clearly perceived. Duration was longer. No auditory image of this persisted, but attention went to a kinaesthetic quiver, particularly the

ears. Then the second stimulus was given, was clearly perceived, and remained relatively long in consciousness. Also aware of attention to a continuation of the quiver about the ears. Then auditory images of first and second stimulations came in again in that order, but these images were not different. These images followed one another very rapidly and were localized respectively to the left and right in a visual-spatial manner. Then the auditory vocal-motor image 'equal.'"

92. Series II. 2/5/15. *45*. 'Equal.' "First stimulus was clearly perceived There was some bodily adjustment to this, particularly about the ears and face, and this adjustment persisted up to the second stimulation. When this second stimulation was perceived I was not aware of any difference in the bodily adjustment following this. Then there was a pause with considerable tension in the vocal apparatus, and finally vocalization of the judgment."

93. Series III. 2/12/15. *35*. 'Softer.' "Immediately following the perception of the first stimulus there was quite an intense tingle in the ear, and the auditory side of this stimulation dropped out immediately, but a facial tension and tension in the ear persisted up to the second stimulus. With the second stimulus I was aware of two things: First, an absence of the tingle in the ear which was present from the first; and secondly, a relaxation in the general facial tension. Judgment was vocalized at once."

94. Series IV. 3/19/15. *60*. 'Louder.' "Immediately after the 'ready' signal, I visualized the apparatus. Adjustment of an attentional sort to the general apparatus region. The first stimulus was perceived quickly and went out of consciousness very rapidly, and I was not aware of any image of it coming in. Then the second stimulus was perceived, and it seems that I must have carried over some sort of facial adjustment because I was now aware for the first time of an increase in strain which had been present in my forehead and jaws. Reflexly, I vocalized the judgment."

The Comparing of Visual Brightnesses

95. Series I. 4/21/15. *7*. 'Darker.' "Just before the stimuli appeared, there was fixation at the right end of the aperture and vocal-motor auditory image of 'darker.' Then the stimuli appeared and the fixation shifted to the white space between the two rectangles, and I perceived both at once. Then fixation turned to the right-hand rectangle, and I just perceived its darkness and reflexly vocalized the judgment."

96. Series I. 4/21/15. *5*. 'Equal.' "Fixation was at first between the two rectangles and I perceived both at once. Vocal-motor image of the word 'equal.' This was followed by rather intense muscular tension, practically all over my body. Then I fixated the left-hand rectangle and I was aware of a sort of halo about it, and also of the washed-out, pale appearance of the center of the rectangle. This apparently drew attention for a considerable

time. I then fixated the right-hand rectangle and this also appeared pale in the middle, and I now had vocal-motor and auditory images of 'equal.' Then fixated the white space between the two, and just as they were disappearing I was fixating the right-hand rectangle, and it appeared very dark. Then I vocalized the judgment in a doubtful and hesitating manner."

97. Series II. 4/28/15. *4.* 'Darker.' "In the fore-period there was close fixation on the aperture, and high degree of tension and restlessness. Then the two stimuli came into the aperture. If I was aware perceptually of the left-hand stimulus at all, it was only for an instant and with a very low degree of clearness. I was fixating the right rectangle and it appeared very dark. Then there was some sort of an organic sensation, and vocal-motor 'darker.' This was followed by relaxation. But I continued to attend to the perception of the rectangles and alternated several times between the right and left-hand ones, but the right one always remained more focal. Then I was focally aware of the right-hand one appearing very dark, and I reflexly vocalized the judgment 'darker.'"

98. Series II. 4/28/15. *4.* 'Darker.' "In the fore-period this experience was characterized by restlessness and strains, particularly about the face and neck, and a tendency to visualize a pair in which neither appeared darker. The two stimuli appeared and there was a perception of the left-hand stimulus, but of very short duration, and as if I were already moving my line of regard to the right-hand stimulus. Then the right-hand rectangle was perceived and stood out as very black, and I reflexly gave the judgment 'darker.' This was followed by general relaxation."

99. Series II. 4/28/15. *1.* 'Lighter.' "In the fore-period I had a visual image of two very dark rectangles which looked to be equal. Unpleasantness and tension in the neck and throat, and inhibited breathing. Vocal-motor auditory process: 'I guess this will be hard.' The two stimuli appeared and there was fixation of the right-hand stimulus at once. It appeared very light. The judgment was vocalized at once with general attentional relaxation. I only looked at the left-hand rectangle as I was turning away, and after the judgment had been given."

100. Series III. 5/5/15. *3.* 'Lighter.' "As the stimuli came into the aperture, I perceived the right-hand stimulus first focally. In the center of this rectangle it appeared pale and washed out. There was a sudden start of the vocal organs to say 'lighter,' and pleasantness and a general bodily relaxation. Before the judgment was vocalized, however, I fixated the left-hand stimulus and immediately vocalized the judgment."

Observer *Wd.*

The Comparing of Lifted Weight Stimuli

101. Series I. 2/25/13. *100.* 'Lighter.' "With the lifting of the first weight the focal thing in consciousness was the kinaesthetic sensations local-

ized primarily in the wrist, slightly in the forearm, and back of the hand. I was non-focally aware of a visual image of my hand grasping the weight. A primary kinaesthetic image of the lifting of the first weight was present throughout the lifting and lowering of the empty hand, and up to the lifting of the second weight. I was then aware of kinaesthetic sensations of considerably less intensity than the image had been. Almost immediately I had in vocal-motor auditory imaginal terms the word 'lighter,' and attention turned at once from the problem."

102. Series I. 2/25/13. *108.* 'Heavier.' "During the lifting of the first weight I was aware of kinaesthetic sensations primarily in the wrist, slightly in the forearm, and over the back of the hand; and a primary image of this remained in consciousness up to the lifting of the second weight. I was then aware with the lifting of the second weight of very much greater intensity of sensation than had been present in my image. I had then a visual image of two weights, one to the right smaller and lighter in color than the one to the left, but this was not focal and was more or less hazy."

103. Series II. 3/11/13. *96.* 'Equal.' "With the lifting of the first stimulus I was aware of kinaesthetic sensations of fairly great intensity, localized in the wrist and forearm. This was followed by an immediate vocal-motor process 'heavy-light,' which meant a characterization of the first stimulus as heavy in absolute terms, and an expectation that the second would be light. This latter was accompanied by motor imagery of reaching to the left as for the second stimulus. This whole process was accompanied by a rather intensive pleasantness. A primary memory image of the kinaesthesis of the first weight, localized particularly in the wrist, persisted up to the lifting of the second weight. When this second stimulus was lifted there was an awareness, particularly in the wrist, of rather intensive kinaesthetic sensations. This was followed immediately by a deep inhalation and inhibition of breathing, and a revulsion of affective toning to rather intensive unpleasantness. By this time the weight was nearly at the top of the lift, and the kinaesthetic sensations of the wrist again became focal. When the weight was at the top of the lift I became focally aware of a kinaesthetic image of the sensations of the lifting of the first weight which were referred to the first weight by a motor imaginal reference toward the right. The intensity of the image of the lifting of the first weight and the sensations which I had just had before of lifting of the second weight seemed to be exactly similar. The judgment was then formulated in vocal-motor terms."

104. Series III. 3/12/13. *104.* 'Heavier.' "With the lifting of the first weight I was aware of sensations of a kinaesthetic sort, localized particularly in the wrist, forearm and back of the hand, in which the wrist was by far the more focal. I now believe that a muscular strain persists from the lifting of the first weight up to the lifting of the second. That is, I do not believe that what is carried over is a real image, but that it is actually an innervation of the muscles. This time there was a conscious determination to keep this muscular feel definitely in mind up to the lifting of the second weight, but I

can not tell how this determination was present. With the lifting of the second weight I was aware of the insufficiency of this motor contraction,—that is, a difficulty in lifting the weight from the table, and then sensations of a kinaesthetic sort which became gradually greater in intensity until the weight was lifted. The judgment came in vocal-motor terms immediately and there was then a turning of attention to other things."

105. Series VII. 4/29/13. *100.* 'Heavier.' "When the first stimulus was lifted there were very clearly in consciousness kinaesthetic sensations principally in the wrist, and also in the forearm and back of the hand, which were of absolutely very light intensity. This was followed by the auditory vocal-motor image 'light-heavier,' in the latter case with manual-motor imagery toward the left. A motor set similar to the lifting of the first weight persisted up to the lifting of the second weight, and with the lifting of the second stimulus I was aware of the fact that the weight did not go so high nor so rapidly, and also that the kinaesthetic sensations, particularly in the wrist, were of greater intensity. This apparently set off the vocal-motor image 'heavier.' "

106. Series VII. 4/29/13. *92.* 'Lighter.' "All I was aware of was a consciousness of kinaesthetic sensations with the lifting of the first weight, which were of fairly great absolute intensity. This was followed by vocal-motor 'fairly heavy—lighter.' There was also a continuation, in what appears to be a motor set, of the kinaesthetic sensations, particularly in the wrist, of the lifting of the first weight up to the lifting of the second stimulus. The second stimulus was lifted, and I was aware of a less intensive degree of kinaesthesis in the wrist than the image which had just preceded it, and this apparently set off in mechanical fashion the vocal-motor image 'lighter.' There seems to be now in every case an absolute estimation of each of these two sensations, as well as the comparison of their intensities. They are apparently compared every time with an average. There seemed to be seven groups of intensities into which each particular weight may fall. There are three grades heavier than the average, and three grades lighter,—that is, very heavy, heavy, fairly heavy, average, fairly light, light, very light. After a perception of the intensity of the kinaesthetic sensations these are characterized in vocal-motor terms, often with concomitant auditory imagery as belonging to one or another of these seven groups. With this characterization of the first stimulus there is often a prophecying in the opposite direction from the average as to what the second weight will be."

107. Series VII. 4/29/13. *88.* 'Lighter.' "With the lifting of the first weight I was aware of fairly intensive kinaesthetic sensations, particularly in the wrist, somewhat in the forearm and hand, and this set off the verbal-motor image 'fairly heavy.' The primary image of this intensity remained up to the lifting of the second weight. I was aware with the lifting of the stimulus of several things: That the intensity of the sensations involved in its lifting was less than the motor set which had lasted up to it, and also that the second weight went up more quickly. There was an immediate vocal-motor image of the word 'lighter.' "

Observer *F.*

The Comparing of Lifted Weight Stimuli

108. Series II. *2/20/13*. *100*. 'Heavier.' "The first weight was lifted and I was aware in tactual terms of the pressure of the fingers in the weight. I grasped each weight just sufficiently to keep it from slipping from the fingers. While the empty hand was lifted and lowered I carried over a tactual image of this pressure up to the lifting of the second weight. I was then aware in tactual terms of the pressure of the fingers on the weight for the lifting of this second stimulus, and they were of greater intensity than the tactual image which had just preceded them. The judgment came at once in vocal-motor terms."

109. Series III. *2/26/13*. *92*. 'Lighter.' "The tactual impression on the ends of the fingers of the second weight compared with a memory image of the tactual impression of the first weight seemed to be the basis for judgment. For the first stimulus there was also a definite idea of its absolute equality, which was present to consciousness in terms of a visual image of a weight slightly heavier than medium. The second stimulus was judged to be of about medium absolute intensity. I am not aware of kinaesthesis playing any part in the judgment."

110. Series IV. *2/27/13*. *100*. 'Equal.' "The judgment again was made by a comparison of the tactual pressure of the weight of the second stimulus on the fingers as compared with an image of the first weight which persisted up to the grasping of the second stimulus. This pressure on the fingers was a serial sort of affair. At first the pressure is upon all of the fingers, but later it is primarily upon the third finger, at least the pressure on the third finger is more focal in consciousness than upon any of the others. The pressure exerted by the second stimulus seemed to be exactly similar to my image of the pressure of the first stimulus."

111. Series VII. *3/20/13*. *88*. 'Lighter.' "I was aware of a tactual sensation on the fingers with the lifting of the first weight, and this was judged to be lighter than medium. An image of this pressure remained over up to the grasping of the second stimulus. Pressure on the tips of the fingers was of much less intensity than this image. The second stimulus was judged clearly to be lighter than medium."

112. Series XI. *4/3/13*. *100*. 'Equal.' "I lifted the first weight and was aware of a tactual sensation on the tips of the fingers, particularly the third, which I judged to be of medium absolute intensity. After replacing the first stimulus, an image of this remained over to the grasping of the second weight, and with the raising of the second weight the sensations of a tactual sort seemed to be of exactly the same intensity as the image, and this weight was also judged to be of medium absolute intensity. I have in consciousness something more than I have been telling you. I have seven classes of absolute weight, and each stimulus as it is lifted is judged to be in one or other of

these classes. These are medium, lighter, still lighter and lightest, slightly heavier than medium, next to heaviest, and heaviest. The weight is put into one of these classes, due to my perception of the tactual intensity almost solely, but now and then a visual and vocal-motor characterization of them."

113. Series XIII. 4/23/13. *104.* 'Equal.' "The first stimulus was judged in terms of the tactual intensity of the sensation as a little heavier than the average. A tactual image of this remained only vaguely for a short time. There were then present in consciousness an anticipatory tactual image of absolutely medium weight. This was held in a visual schema and the tactual sensations due to the lifting of the second weight were actually perceived as one grade heavier than medium. This visual schema as a working basis is a series of seven vague gray splotches extending from left to right in front of me, and indicating the position of each of the intensities of the sensation. The medium intensity is directly in front of me, the lightest to the left, and heaviest to the right, with two grades between the heaviest and medium and the lightest and medium. There is imagery of fixation of the line of regard upon the point in this schema corresponding to the intensity of the tactual sensations of each weight lifted, and that point in the schema also appears with a greater degree of visual clearness."

Observer *P.*

The Comparing of Lifted Weight Stimuli

114. Series III. 3/1/13. *93.* 'Lighter.' "The first stimulus was lifted and I was aware of kinaesthetic sensations in the hand, particularly in the fingers, which were in very strained condition. An image corresponding in intensity to these sensations was present up to the lifting of the second weight. This second stimulus was lifted and I was aware of kinaesthetic sensations in the hand which was of less intensity than the image just preceding."

115. Series III. 3/1/13. *88.* 'Lighter.' "With the lifting of the first weight I was aware first of pressure of the weight on the finger-tips, and these were of very great absolute intensity. I was then aware of kinaesthetic sensations of the lifting of the first weight, and these remained in imagery up to the lifting of the second weight. I tried to lift the weight with the same intensity corresponding to this kinaesthetic image, and here I was aware that the hand went higher and that there was more strain across the fingers. The hand also went up faster with the lifting of the second weight and the tactual sensations seemed to be absolutely very light. The hand gave a little jerk upward immediately upon the grasping of the second weight; the judgment seemed to be made at once upon the perception of this."

116. Series IV. 3/3/13. *108.* 'Heavier.' "The first weight was lifted with a certain swing to it, and I was aware of the intensity of the kinaesthetic sensations, localized particularly in the forearm and hand, and of the sensations of contact on the end of the fingers. An image of these lasted up to the lifting of the second weight. The second weight was grasped with the same intensity of contact, and the same amount of energy was put into the

lifting. It now seems that the pressure sensations are no longer a variable element as I seemed to be grasping the weight with approximately the same force. As the second weight was returned to the table, the judgment 'heavier' was formulated, due to the great intensity of the kinaesthetic sensations, particularly in the hand. I am unable to tell any difference in the space over which these sensations were localized. It seems to be more a matter of a comparison of the intensiveness of these sensations."

117. Series VII. 3/14/13. *92*. 'Lighter.' "With the lifting of the first weight there was very focally in consciousness the intensity of the kinaesthetic strains in the fingers and hand and forearm. An image of these remained in consciousness up to the lifting of the second weight, and this stimulus was lifted with the same swing and to the same height. This second stimulus came away from the table more rapidly than the first weight, and the judgment 'lighter' was formulated in vocal-motor terms at once. There did not seem to be such a marked difference in weight, but there was a marked difference in the speed with which the up-stroke was made."

118. Series XI. 3/21/13. *88*. 'Lighter.' "With the lifting of the first weight there was very clear sensation of a kinaesthetic sort in the muscles of the forearm, and also in the joints of the wrist and the fingers. An image of these, but particularly of the muscular sensations of the forearm, remained up to the lifting of the second stimulus. This was lifted with the same amount of force and came away lighter. In the early part of the lifting of the second stimulus, the speed was greater and the judgment made almost at once."

119. Series XXIV. 6/3/13. *96*. 'Equal.' "With the lifting of the first weight I was aware of kinaesthetic sensations, particularly in the forearm, also in the wrist and fingers, which were of light absolute intensity. With the replacing of this first stimulus the intensity of these sensations was imaged, and it persisted between the raising and lowering of the empty hand. The second stimulus was lifted in the presence of kinaesthetic imagery of the first stimulus, and I was then aware of the kinaesthetic sensations particularly in the forearm, these being the most focal, involved in the lifting of the second stimulus. And I was unable to see any difference in the intensity between them and the image. No judgment was formulated, however, until the second weight was replaced upon the table, when the judgment was formulated in vocal-motor auditory terms. I am in the attitude of looking for a difference and this time, as always, there was unpleasantness when I could not find a difference. This weight is simply subjectively equal as I could not bring out the difference of the intensity of the two sensations. But there is no feeling of equality like I have often gotten from a feeling of difference."

Observer *B*.

The Comparing of Visual Extents

120. Series II. 10/14/14. *154*. 'Longer.' "I was very conscious of eye-movement from one line to the other from right to left across each line

several times. And the judgment did not come until the second comparison. I had a visual image of the left-hand line above the right-hand line and the right-hand line extended out to the right beyond the image. There was also a comparison of kinaesthetic images of the movement over the two lines as the eye-movements were very much involved."

121. Series II. 10/14/14. *152*. 'Equal.' "Attention and fixation first upon the righthand stimulus, which was perceived clearly. Then eye-movement and perception of the left-hand stimulus, and judgment that the right-hand stimulus was longer. Then a return of fixation to the right-hand stimulus, and an 'equal' judgment developed. Throughout this portion I was very conscious of eye-movement and the judgment was made in terms of it. Very concentrated attention up to the moment of the formulation of the final judgment, following which there was relaxation. I had more of a comparison consciousness here. I carried over a kinaesthetic image of the first stimulus and definitely compared it with the kinaesthesis of moving across the second stimulus. I should say that I had more of a relational consciousness. The process throughout was marked by slight unpleasantness."

122. Series III. 10/28/14. *154*. 'Equal.' "When the lines came into view there was a perception of the left-hand stimulus in visual terms, and without any consciousness of kinaesthesis but with attention keenly upon this line. I then perceived the right-hand stimulus and a visual image of the left-hand line lingered in consciousness. It seemed as if this image and the perception of the right-hand line were present simultaneously at the moment of the judgment, with attention upon the perception of the right-hand line, however. The image of the left-hand line was above the right-hand line, when both were present simultaneously, the left-hand ends being together and both extending the same distance to the right."

123. Series IV. 11/4/14. *144*. 'Equal.' "The visual perception of the left-hand stimulus with visual fixation on the center of the line. I am conscious of trying to perceive the line as a whole and without eye-movement. Shift of fixation to the center of the right-hand stimulus, and I was then aware of a visual image of the left-hand line above the right-hand line with about a quarter of an inch above the right-hand line. And the right and left ends of the line, and the image were in a similar position. The judgment was expressed in verbal terms, and there was a relational consciousness which was a spatial relation."

124. Series IV. 11/24/14. *156*. 'Longer.' "Fixation was on the center of the left-hand line, but I am sure that there was eye-movement before I perceived this line as a whole. I carried over a visual image of the left-hand line to the right-hand line, and this was superimposed above the right-hand line, but the right end of the image did not extend out so far. There was also some kinaesthesis involved in the perception of the right-hand line which I believe was as influential in the formation of the judgment as the visual image. That is, as my eye was moving across the right-hand line I

was aware of the eye stopping for a moment and then proceeding onward, and apparently this hitch in the eye-movement indicated the point where the othet line would have stopped."

125. Series VI. 12/2/14. *154.* 'Longer.' "Fixation on the left end of the left line as the stimulus appeared in the aperture. This was followed by consciousness of eye-movement in motor terms across the end of this line with fixation for a considerable time on the right end of this line. Then eye-movement to the left end of the right-hand line, and eye-movement across this line. This eye-movement, however, halted just a little before the end of the line was reached, and the very end of the line stood out very clearly in visual perceptual terms. I was aware then of the judgment being vocalized at once."

The Comparing of Auditory Stimuli

126. Series I. 1/27/15. *60.* 'Louder.' "In the fore-period there was distinct muscular strain about the head and attention toward the instrument, and fragmentary vocal-motor and auditory imagery of the instructions. When the first sound was given, I was conscious of a muscular image of the forward movement of the head and of a tension in the mouth and tongue; also pressure in the upper chest, due to suspended breathing. There was also attention, at the time of the sound, to the sound itself, and sustained attention to an image of the first sound. That is, the first sound tailed off slowly and was just disappearing when the second sound was given. This was perceived and the judgment 'louder' came immediately, but I can not say how it was present."

127. Series I. 1/27/15. *65.* 'Louder.' "In the fore-period I was distinctly conscious of drawing in the breath and holding it. Then perception of the first sound, and at once I gave a reflex jump, either organic or kinaesthetic, and I believe that this was the criterion of my judgment. The general breathing strains and strains in the head carried over from the first to the second stimulus. Then after the perception of the second stimulus there was a slight pause,—that is, it seemed as if it took me longer to perceive the second stimulus than usual. I was consciousness of the slowness of my own relaxation. After the second stimulus there was a jump and this comes every time. The judgment was given with the greatest subjective assurance."

128. Series II. 2/10/15. *65.* 'Louder.' "In the fore-period there was strain, inhibition of general movement, and pressure from suspended breathing, and also tensions about the head, especially in the forehead. This whole kinaesthetic and organic condition of strain remained until the sound of the second stimulus, and increased between the first and second stimulus. With the perception of the first stimulus there was vague visual imagery of a falling hammer to the left; and again a visual image of a falling hammer to the right, with the perception of the second stimulus. The auditory image of the first stimulus did not carry over to the second stimulation. The second stimulus was more intense, and this seemed to be in a greater degree of tension for the second than for the first stimulus."

129. Series II. 2/10/15. *55.* 'Louder.' "The same tensions that seemed to be connected with attention in the fore-period. With the first stimulus there was kinaesthesis in head and body (a general sort of moving forward); and a general intake of breath of which I was conscious mostly in the throat and diaphragm. This did not release in the interval between the first and second stimulus, but increased after the second stimulus. The criterion of judgment here seemed to be entirely kinaesthesis. After the second stimulus there was total release of these tensions."

The Comparing of Visual Brightnesses

130. Series I. 4/21/15. *6.* 'Darker.' "Fixation was between the left and right-hand stimulus, slightly toward the right-hand one. When the stimuli came into the field of vision I was conscious of the white between and a portion of the grays to the right and left of this. The judgment was made before the entire card came into view. No fluctuation of eye-movement, and the whole process was of slight duration."

131. Series I. 4/21/15. *5.* 'Equal.' "In the fore-period there was pressure and strains connected with tension and with irregular breathing. Fixation was about half an inch from the left-hand end of the right stimulus, then travelled over the left-hand stimulus across the white space to the right-hand stimulus. The two central edges of the grays were the only parts that came into direct vision. The breathing and kinaesthetic complex continued; vocal-motor 'darker,' 'equal' fluctuating a number of times, and with continued fluctuations of eye-movements between the two grays. Then for a moment both the grays were in the focus of attention, and the judgment 'equal' in vocal-motor terms followed immediately. With the judgment came relaxation and change in breathing."

132. Series II. 5/5/15. *2.* 'Lighter.' "I started out with a definite *Aufgabe* to avoid eye-movements. This latter was present in vocal-motor terms in considerable strains about the eyes and brow. When the exposure was made, however, there were very slight eye-movements, but I think that the vocal-motor judgment 'lighter' came before that flicker of eye-movement, and when the right-hand stimulus was becoming focal the left-hand stimulus was also very distinct, and I was aware that they were different. This experience of difference in quality and degree I am unable to analyze."

133. Series IV. 5/19/15. *2.* 'Lighter.' "The fore-period was taken up with strains and inhibited breathing, and fixation of the revolving drum. Then the right-hand stimulus came into focus of attention, and the left-hand in peripheral vision. I was not conscious of eye-movement until after the judgment 'lighter.' That word came immediately upon the perception of the right-hand stimulus as a light gray."

134. Series IV. 5/19/15. *6.* 'Darker.' "Line of regard and attention focused on the center of right-hand stimulus. This gray appeared intensely

black. The left-hand stimulus was in peripheral vision only; with consciousness of the intensity of the black of the right-hand stimulus came the vocal-motor image 'darker.' Then eye-movement to the left-hand stimulus, back to the right, and then relaxation."

Observer *T.*

The Comparing of Visual Extents

Due to this subject's inexperience in introspection, his individual introspections are too incomplete and too fragmentary to make it worth while for us to quote any, as the process was not sufficiently analyzed.

The Comparing of Auditory Intensities

135. Series II. 2/10/15. *60.* 'Louder.' "With the perception of the first sound there was an inhalation and a holding of breath at the complete phase of this inhalation up to the perception of the second sound. There was then a deeper inhalation followed immediately by a complete exhalation. The judgment seemed to be merely a matter of the amount of breathing. The swinging of the pendulum was also imaged in terms of eye-movement."

136. Series III. 2/10/15. *45.* 'Softer.' "The judgment this time was again a matter of breathing. Inhalation to a certain extent after the first stimulus, and an awareness of the holding of this in terms of a slight pressure across the chest. After the perception of the second stimulus there was a slight exhalation which was checked, and then complete exhalation."

137. Series IV. 3/17/15. *45.* 'Louder.' "Perception of the first stimulus and I was aware of swaying slightly forward in my chair; at the end of this excursion my body became rigid and stayed in this position. This set was maintained up to the perception of the second stimulus. Immediately after this perception of the second stimulus there was very slight swaying of the body further than had been before. Then I was aware of strains in the vocal organs, nod of the head forward, and vocalization of the judgment. During this later period I repeated the swaying of my body for both the first and second stimuli as a sort of verification."

138. Series IV. 3/17/15. *40.* 'Softer.' "With the perception of the first stimulus there was a very slight bending forward, with awareness of kinaesthesis in the knee and across the abdomen. And this set was held up to the perception of the second stimulus. With the perception of the second stimulus there was a bending forward of the head and a dropping of the chin on the chest, and a sinking in the abdomen as if in exhalation. Perception of these was followed immediately by the verbalization of the judgment."

2. *Individual Analyses or Case Studies of the Process of Comparing*

In the following section we shall attempt to give a description of the process of comparing for the different subjects and for the different sorts of stimuli. This will be in the nature of a summary of the introspections for each group of experiments and for every observer. We shall consider the nature of the process of comparing for the different stages of practice in each case.

Observer *W*.

The Comparing of Lifted Weight Stimuli

In the early stages of practice many criteria seemed to function in the process of comparing for this subject. He was aware of pressure sensations on the fingers; of kinaesthetic sensations localized in the joints of the fingers, in the wrist and forearm. Also, at this stage of practice, a visualization of the experimental situation and a visual schema of the judgment seemed to be always present. One or any combination of these criteria might be particularly focal in any single experience. In the early stages of practice, then, the images of comparison were usually complex with several modalities involved,—tactual, kinaesthetic and visual,—entering into the process, but usually with one of these more focal than the others. (1, 2, 3, 4, 5, 6, 7, p. 18 ff.)[1]

These images frequently remained in consciousness throughout the period between the replacing of the first weight and the lifting of the second weight and apparently the judgment of difference was made on the basis of a perception of greater or less intensity of sensation than the intensity of this image. There is no evidence that the image and sensation were ever present simultaneously in consciousness. At this early stage of practice for this subject a visual schema of the judgment seemed to be necessary or at least was invariably present, before the judgment was formulated in verbal terms. In this visual schema, the lighter weight was visualized as small, light in color and high from the table; the heavier weight was visualized as larger, darker in color and closer to the table. Also the rapidity of movement of the hand and weight and the muscles of the arm were visualized at this stage of practice. In this schema, the standard weight was

[1] The numbers in parenthesis refer to the arbitrary serial numbers of the actual introspections given earlier in the paper. The page reference for these particular introspections is also included in the parenthesis.

always visualized to the left (the direction in which it had gone when the table had been turned) and the comparison weight was always visualized to the right. At this early stage of practice the doubtful judgments resulted from the fact that the subject, for some reason, was not able to recall a clear tactual-kinaesthetic image of the lifting of the first weight (6, p. 20). In this case, there was usually an effort to recall an image of the lifting of the first weight, when the comparison stimulus was at the top of the lift and stationary, just before it was lowered. In this case only did the down stroke of replacing the second weight ever function for this subject. Usually the sensations of lifting the second weight were clear and then these sensations dropped out of consciousness entirely. Judgments of true subjective equality occured during this early stage of practice for this subject (7. p. 20 f.). and seemed to be as rapidly formulated as were the judgments of difference.

At a later stage of practice, it appeared as if this subject had singled out one single sensation from the general tactual-kinaesthetic complex of the lifting of the standard stimulus, and this was carried over to the lifting of the second weight. This subject would be aware of the entire complex during the actual lifting of the first weight but only the muscular sensations localized in the forearm remained in consciousness after the replacing of this weight. At the earlier stages of this later period of practice, this muscular residue was described as an image (8. p. 21). Later this muscular residue was described as a definite motor set or preparation for the lifting of the second weight, occasioned by the lifting of the first weight. This motor preparation, it turned out, was an actual innervation of the muscles of the forearm, and the subject in the later experience described it as a "tetanus condition" (9, 10, 11, 12, p. 21 f.). The judgment was now formulated on the basis of a perception of the movement of the arm during the lifting of the second weight. The perception that the arm went up rapidly or higher led to a lighter judgment; the perception that the arm went up slower or less high led to a heavier judgment. At this stage of practice the subject did not depend upon a visualization of the process to such a great extent as before; indeed his visual schema of the judgment seldom came into consciousness until after the judgment had been verbalized. Very few doubtful judgments were given in the later experiments. Practically all of the equality judgments were good cases of real subjective equality. In the case of the equality judgments, there was invariably a verification of the judgment at the top of the lift of the second weight, when this weight was poised and not moving, at which time a clear kinaesthetic image of the lifting of the first weight, referred to the left in a visual spatial manner, came into consciousness for a short time (12. p. 22). At no time did this subject report that affective processes came into consciousness until after the judgment had been formulated, and then these affective processes seemed to refer to the ease and certainty of the judgment. For this subject, then, the entire process of comparing was complete before he began to lower the comparison weight to the table.

The Comparing of Visual Extents

For the visual comparing of lengths of lines, we find for this subject, in the early stages of practice, that a relatively large number of criteria were employed. Very infrequently he employed visual imagery in his comparisons, although at times a visual image of the standard line would be in consciousness, projected directly above the perceived comparison line. This usually occurred late in the formulation of the judgment and was in the nature of a verification process. Kinaesthetic criteria were employed almost invariably in the judgments of this early stage. These were of three sorts: 1. strains of the external eye muscles at the moment of arriving at the end of the line after the eyes had moved across the stimulus; 2. judgments in terms of the duration of these sweeping movements; 3. strains of accommodation described by the subject as being of a circular sort localized definitely within the eye and referred to the lens and corneal region. In the early stages of practice all of these criteria might be employed successively in a single discrimination (13, 14, 15, 16, 17, 18. p. 22 ff). The awareness of difference was due to a perception of an increase or decrease of strains of eye movement as the line of regard reached the end of the second stimulus. At other times the subject fixated the middle of the first line and carried over the strains of accommodation to the second line and then was aware of an increase in the intensity of these strains or of a partial relaxation. One other criterion was used at times but very infrequently. This was of a more immediately perceptual sort. In this experience the subject fixated a point midway between the lines and then gradually there was a widening of the perceptual field until the outer ends of both lines came within the field of perception (18. p. 26 f.). Judgments of equality at this stage of practice were made on the basis of the same criteria as were the difference judgments but the processes were usually longer and more intricate (16, 17, 18. p. 25 ff.). For the equality judgments, in the case of the use of kinaesthetic criteria, the judgment was in negative terms, *i.e.* there was "no change" in this motor set or preparation carried over from the first to the second line. This was usually followed by unpleasantness and a rapid perceptual alternation of the two lines and the employing of other criteria. It is of interest to note that this subject who used visual images to a very considerable extent in other situations, did not use images of this modality except infrequently and then only in the nature of a verification process, in the experimental arrangement with visual stimuli. Absolute judgments also played a small part in the equality judgments but again were in the nature of a verification process. These absolute judgments were made largely on the basis of the duration of the eye movements in sweeping over the lines.

Gradually this subject came to use solely the criterion of the strains of accommodation in making comparisons with this sort of material (19, 20, 21, 22, 23, p. 27 ff.). Indeed, he came to the point, after considerable practice, of making a comparison judgment without ever perceiving the standard line at all. That is, the general experimental situation was apparently sufficient to cause the assumption of the strains of accommodation necessary for just perceiving the standard line. When the stimuli came to rest in the exposure field, this subject approached the comparison line with this motor set and the judgment of difference was at once formulated on the basis of a perception of an increase or decrease of the intensity of these accommodation strains. This increase or decrease of the intensity of the strains of accommodation was followed by a clear visual perception of the whole of the comparison line. In case, however, that this subject was not aware of any change in the intensity of these strains of accommodation, the equality judgments were not so immediate (23 p. 29.). In that case there was a rapid perceptual alternation between the two lines with the strains of accommodation more focal in consciousness than the visual perceptions themselves and the judgment developed more gradually.

The Comparing of Auditory Intensities

In the comparing of sound intensities it is of interest to note that, from the very beginning of experimentation with this subject, the auditory criteria were seldom focal in consciousness. Auditory images of the standard stimulus were at times present to consciousness until the sounding of the comparison stimulus but not frequently (26. p. 31.). Certain auditory criteria such as the voluminousness of the sound sometimes stood out (29. p. 32 f.). In the early stages of practice a visual schema of the sound was very focal (24, 25, 26, 27. p. 30 ff.). This visual schema seemed to be a hazy line,—described as being like the "tail of a comet." This line was long for the loud sounds and short for the soft ones. The visual schema for the standard sound was always localized toward the left, and that for the comparison sound was localized toward the right. This visual schema seemed to be very important and apparently mediated in the formation of absolute judgments regarding the intensity of the stimuli.

The principal criteria for all stages of practice, however, were of a kinaesthetic sort as will be seen in all of the introspections quoted for this subject in this experimental series. Immediately following the auditory perception of the standard stimulus there was a muscular contraction which was held over until the second stimulation. Following the second sound stimulus, the subject was aware of an increase or decrease of the intensity of these strains, which lead to a judgment of difference; or of no change in the strain intensity which led to an equality judgment. At the beginning of practice these strains were very general, involving the eyes, face, neck, throat, shoulders, chest and abdomen and there were also verbal motor images of singing the tones. Gradually, as the experiment proceeded, these strains,—or at least those focally present to consciousness,—were of much less extent, involving only the neck, face and shoulders.

Judgments of good subjective equality were given which were quite as immediate as the difference judgments (27, p. 32.). In these cases an awareness that no change had taken place seemed to be as immediate as the awareness of a change in the intensity of the strains which led to the difference judgments. Most of the equality judgments, however, were less immediate (28, p. 32.). In these cases, the first awareness that no change had taken place in the intensity of the strains, led to the rehabilitation of both experiences as a sort of a verification process. This rehabilitation was in imaginal terms and consisted of auditory images, kinaesthetic reactions and the visual schematization. Any one of these three elements might be the most focal,—this varied from one experience to another.

Observer *Fs.*

Comparing of Lifted Weight Stimuli

In the early stages of practice, the process of comparing for this subject seemed to be already fairly mechanized, although she had had no previous training in our particular experimental technique. The focal processes consisted in a clear awareness of the kinaesthetic sensations involved in the lifting of the standard stimulus. These were localized in the dorsal side of the hand, wrist and forearm. A primary image of these kinaesthetic sensations remained focally in consciousness up to the lifting of the comparison weight. This observer reported that this memory image tailed off and had to be renewed several times during this interval by actual innervation (30, p. 33.). The comparison stimulus was lifted in the presence of this image of the lifting of the first weight and the judgment was formulated on the basis of two sorts of criteria. In some experiences, this subject might be aware that the sensations, localized in the arm, wrist and hand, were of the same or of different intensity from the image which had just preceded them. The introspections show that this was an immediate awareness (30, p. 33). In other experiences the subject might be aware that the hand had gone up differently in the second lifting,—higher and more rapidly in the case of a lighter judgment; more slowly and less high in the case of a heavier judgment. This sort of criterion seemed to be mediated by a visual image of the hand and of the hand movements (30, 36, p. 34 f.). Indeed, for this observer in the early stages of practice, there was a running accompaniment of visual images of the experimental situation. These, however, were usually described as being less focal than the kinaesthetic components (30, 31, p. 33). At this stage of practice the judgment was frequently formulated in terms of a visual image of the two weights, in which the lighter weight appeared less dense than the heavier one (31, p. 33).

Practice made relatively little difference in the process of comparing lifted weights for this subject. The kinaesthetic criteria already described were employed throughout the experiment. In other words, the comparison stimulus was always lifted in the presence of a kinaesthetic image of the lifting of the standard stimulus, refreshed from time to time by actual innervation, and the subject was apparently immediately aware of a change of intensity of sensation as compared with the image, or of a difference in the way in which the hand moved in the case of the difference judgments (32, 33, 34, p. 33 f.). In the case of the equality judgments, the process was the same, and the subject merely noted that there was no difference between the image and the subsequent sensation (35, 36, p. 34 f.). This might either be a positive sort of judgment, that the sensations of the lifting of the comparison stimulus "duplicated" the image of the lifting of the standard just preceding (35, p. 34.); or it might be a negative judgment of "no difference" between the intensities of the sensation and the image (36, p. 34 f.). In the case of the positive type of experience, the judgment was usually vocalized at once. In the case of the negative judgment, however, there was usually a verification process in visual imaginal terms. The "no difference" type of judgment was given with as high a degree of subjective assurance as was the judgment of positive equality.

With increased practice we do note a tendency for the visualization of the entire process to become less focal and eventually to drop out entirely. Also the vocalization of the judgment becomes exceedingly automatic for this subject. Absolute judgments were sometimes made, always in terms of the absolute intensity of the sensations of a kinaesthetic sort used in the lifting (33, p. 33 f.).

The Comparing of Visual Extents

This observer, in the early stages of practice, made her initial judgments in terms of eye-movements across the lines (37, 38, 39, p. 35 f.). In this experience the line of regard moved across the standard stimulus, more rapidly across the middle of the line than at either end. Then there was a similar movement across the comparison line. At the end of this eye-movement across the comparison line, this observer would find herself fixating either: 1. the exact end of this line (39, p. 35 f.) which would lead to a judgment of equality; 2. a portion of the line near its end (38, p. 35), which would lead to a judgment of greater; or 3. a portion of the white card beyond the line (37, p. 37), which would lead to a judgment of shorter. The visual perception of this portion of the line or of the card would stand out very clearly and focally in consciousness.[1] Certain absolute judgments were made, usually on the basis of the duration of the movement of the eyes across the line (38, p. 35).

Later *Fs'* method of comparing changed considerably with practice. She later reported (40, 41, 42, 43, 44, p. 36 f.) that her method was to fixate the middle of the standard line "which then

[1] This subject was of a highly visual type in the usual situations. It is natural then, that the visual perceptions were reported as being more focal than the kinaesthetic factors. Indeed, toward the end of this set of experiments, we found that this subject had never had a clear and focal awareness of the sensations of changes of visual accommodation. This was determined when we had her perform the classic experiment of fixating one eye in a mirror and then bringing this rapidly toward her.

stood out as a whole" in visual perceptual terms, and then rapidly shift the fixation to the middle of the comparison line "which then stood out clearly in visual perceptual fashion as a whole." At this stage she frequently used such expressions as "the lines stood out as equal" or "the right hand line stood out as shorter." The vocalization was very automatic in the later stages of practice and indeed this subject reported that she was aware of the beginning of the formation of the vocal organs to verbalize the judgment immediately upon the perception of the comparison line (43, p. 36 f.). Later, after we had demonstrated the sensations of accommodation to *Fs.*, she gave evidence that these were factors in her process of comparing, although the visual perception of the line was always the more focal (44, p. 37.). Judgments of equality were usually followed by an alternating perception of the two lines, a process which might continue throughout the entire period of the exposure (41, p. 36.).

The Comparing of Auditory Intensities

There were three general types of process in this observer's comparing of auditory intensities. The first of these consisted largely in an auditory analysis of the two tones (47, p. 38 f.). For example, the perception of one tone would be accompanied by a "jangling" which would not be present for the other stimulus; and the tone in which this jangling or ringing was noticed would be judged the louder. This subject was unable to analyse whether this jangling was a purely auditory factor or whether it involved kinaesthesis within the ear as well. She rather inclined toward the more complex concept of both kinaesthetic and auditory factors.

Another usual type of process consisted in an auditory image of the first tone remaining in consciousness until the perception of the second tone. This auditory image was frequently accompanied by a vocal motor image or at times an actual vocal motor set. The judgment was formulated in terms of an immediate awareness of change in tone or change in vocal motor set (45, 46, 48, 49, p. 37 ff.). Another type of processes consisted frequently in a kinaesthetic reaction to the first stimulus which consisted in a muscular contraction particularly about the eyes and face. This would be held over until the perception of the second tone, and the subject reported that she was then aware of an increase or decrease in the intensity of these strains of the "cringe" following the second stimulus (46, 48, p. 38 f.). Very frequently several or all of these factors were present in the same experience with, at the different times, one or another of these being the more focal. *Fs.* also reported a visualization of the entire process (45, 48, 49, p. 37 ff.), which frequently developed into a visual schema of two gray spots representing the sounds,—that spot which stood out most clearly in the visual image representing the louder sound. The equality judgments were usually followed by a verification process in which the entire experiences,—auditory, vocal motor of humming and kinaesthetic cringe,—were rehabilitated (49, p. 39 f.).

Practice seemed to have little effect upon the process of comparing for this subject in this experimental series. There was a slight tendency for the visualization of the experimental situation to drop out and also there was a tendency for the kinaesthetic factors to become more focal at the expense of the auditory factors but neither of these tendencies were very marked.

The Comparing of Visual Brightnesses

The process of comparing greys for this observer was exceedingly mechanized from the beginning of the experimental series and did not change materially as a result of the practice which this subject obtained during experimentation. From the point of view of the perception of the stimuli, the following eye-movements were noted with entire regularity. *Fs.*, in the fore-period, would fixate a point below where the stimuli would come to rest. When she was aware, in indirect vision that the stimuli were at rest in the aperture, she would then rapidly move the eyes upward and slightly to the left, then slightly toward the right and then downward to the original point of fixation (50, 51, 52, p. 40 f.). These eye-movements were very rapid but they were present in consciousness in terms of a change in the visual perceptual field rather than as kinaesthetic sensations. As a result of this procedure, this subject had a rapid successive visual perception of the central part only of the standard and comparison stimuli. The comparison stimulus was always slightly more clearly perceived than the standard. Then the subject merely reported a vocalization of the judgment.

Observer O.

The Comparing of Visual Extents

This subject, throughout the experiment, always perceived the comparison line first and, after an examination of this line, he turned to the standard. His process, which was exceedingly simple from the start, changed particularly not at all as a result of the practice which he obtained during the experimentation.

O's judgments were always made in terms of kinaesthesis of eye-movements (53, 54, 55, 56, 57, 58, p. 41 ff.). There would be eye-movements usually back and forth over the comparison line with the strains in the eye muscles at the end of the excursion as the most focal thing in consciousness. The visual perception of the line was always relatively focal, however. Then there was a change of fixation to the standard line. It later turned out that this change of fixation actually involved head movement (57, 58, p. 42 f.). Then there was a visual perception of this line with focal awareness of the kinaesthesis of eye-movement, present to consciousness in the muscular sensations aroused in the external eye muscles. The subject reported a "hitch" in this movement at a certain point and then he found that he was clearly perceiving a point either on the line, at the end of the line or beyond the line. The first and last of these situations led to a difference judgment, while the other led to a judgment of equality. In the case of a judgment of equality (55, 58, p. 42 f.) unpleasantness was invariably present to consciousness with an increase of general bodily strains and a continuation of the process of comparing until the end of the exposure. At one time during the course of experimentation, the subject set himself the conscious *Aufgabe* of spending most of the time in the examination of the comparison line and then making one rapid glance at the standard (57, p. 42 f.). This procedure was soon abandoned.

The Comparing of Sound Intensities

The process of comparing sound intensities for this subject was again very similar for all stages of practice. The process started with the auditory perception of the standard sound which was followed at once by a focal kinaesthetic reaction of the subject singing the sound. There were also other kinaesthetic reactions to the first stimulus such as closure of the eyes (64, p. 45.); movement of the head forward (59, 63, p. 43 f.); kinaesthesis on neck and shoulders and other parts of the body (59, 60, 64, p. 43 ff.). These sensations were usually less clear than the vocal-motor reaction. There was also an auditory image of the first tone which was described as remaining at the same intensity as the standard stimulus but losing in voluminousness (62, p. 44.). This auditory image and the entire vocal-motor and kinaesthetic set, which latter was always the more focal, remained in consciousness without interruption up to the perception of the comparison stimulus. This second sound was perceived clearly but was only of short duration. then the subject was aware of one of three things: 1. a relaxation in the vocal-motor and body strains which led to a judgment of softer; 2. an increase in the intensity of these strains which led to a judgment of louder; or 3. no change in the intensity of these strains which led to an equality judgment. Infrequently (59, p. 43 f.) in the case of the equality judgments, the auditory perception was noted as "fitting into the image." For the difference judgments, however, this subject did not speak of the auditory image of the standard stimulus, except that it appeared non-focally. The relaxations and increases in muscular tensions were all that he reported in these cases after the perception of the comparison stimulus. There did not seem to be any difference for *O.* in the immediacy of the equality and difference judgments. He, apparently, perceived "no change" in the kinaesthetic set as immediately as he perceived a change in either direction. In other words, there was no verification process for the equality judgments and the perception of "no change" was made with as high a degree of subjective assurance as was the perception of change in the kinaesthetic set.

The Comparing of Visual Brightnesses

In the early stages of practice, this observer reported first a fixation and clear perception of the standard stimulus with the comparison stimulus seen in peripheral vision (65, 66, p. 45.). In spite of the fact that the comparison gray was present in peripheral vision, this subject made an absolute judgment upon it, which was apparently an immediate perceptual process plus invariably a vocal-motor image of the words "light" or "dark" as the case might be. Then there was a clear perception of the comparison gray of short duration which was followed by the vocalization of the judgment. At times a verification process of reperceiving the standard gray occurred.

Very soon, however, *O's* procedure changed and he at once fixated the comparison gray (67, 68, 69, 70, p. 45 f.). In the case of a difference judgment he made merely an absolute judgment of the brightness of the comparison stimulus, apparently an immediate perceptual experience plus the vocal motor image of the word. At times (67, 69, p. 45 f.) the standard gray would then be clearly perceived as a verification process. At other times (68, p. 46) relaxation and a turning from the problem would follow this absolute judgment. The equality judgments started in the same way (70, p. 46) but there was always an alternation and rapid successive perception of the two grays several times before the process was ended.

Observer *S*.

The Comparing of Visual Extents

This subject employed a great number of factors in his judgment of visual lengths. It is interesting to note that two or more of his different methods of comparing seldom appeared in any single experience. Each experience, in other words, employed only one method of comparing; while the particular methods employed show a great deal of variation.

In a number of cases visual comparisons were made. In some experiences a visual image of a short perpendicular line would be projected toward the end of the longer stimulus, marking off the length which corresponded to the shorter stimulus line (71, p. 46 f.). At other times a visual image of the standard line would be superimposed upon the comparison line and would extend beyond the end, up to the end or fail to reach the end of this line (77, p. 48.). Muscular factors were frequently involved and these were of various sorts. There would be eye-movements across the standard and comparison lines with the strains at the moment of stopping the movement at the end of the line standing out with great clearness; and the judgment was made in terms of a perception of the intensity of these strains (72, p. 47). Another form of process was to fixate between the lines and have a perception of strain in one or the other side of the body, which was always the side toward the longer line (73, p. 47). *S.* never properly analysed this experience and the actual process remains more or less of a mystery. Another most ingenious kinaesthetic method of comparing the lines was carried on in terms of manual motor imagery. The observer had a manual-motor image of "compassing" one line with thumb and forefinger. This was then carried over in terms of a motor set and the other line was similarly "measured" and judgment given (71, 78, p. 46 ff.). In the cases where this procedure was employed the sensations of strain in the hand were reported as being more focal than the visual perception of the line.

Judgments of a more or less absolute nature were frequent for this observer, particularly in the later experiences. Indeed, the fact that the absolute judgments became relatively more frequent seems to be one of the few effects of practice for this subject. An absolute judgment of length, which was described as an immediate perceptual process by this subject, was almost always accompanied by a curious visual perceptual illusion of the thickness and blackness of the line. The long lines were described as appearing thin and the short lines as thick and black (74, 75, 76, p. 47 f.). Another effect of practice was that *S.* came to the point of making his judgment immediately upon a perception of the comparison line, which was judged in absolute terms (74, 75, p. 47 f.). It afterward turned out (75, 76, p. 47 f.) that one factor in this absolute judgment of the comparison line was the holding over of a muscular set, variously described as localized in the arms, neck and eyes, of the length of the comparison line of the pair before. One result of this was a frequent anticipation of the judgment before the pair was exposed. This anticipation was almost invariably in terms of a visual image of a pair of lines having the spatial relations of the form of the anticipated judgment (76, p. 48). In all of these processes, indeed for every experience for this observer, there was a verification process which consisted of a repetition of the same process employed, if the standard line had been first perceived. If, however, a judgment had been made after a mere perception of the comparison line, the verification process might only consist of a subsequent clear perception of the standard stimulus. The only difference which we can find between the nature of the processes which led to the difference or equality judgments is that in the latter case this verification of the judgments was repeated more frequently and was of greater duration.

The Comparing of Auditory Intensities

This subject gave introspective descriptions of his process of comparing stimuli of this modality, which in their essential features showed monotonous similarity. There was usually, in the fore-period, an anticipation of the experimental situation in visual, auditory and kinaesthetic imaginal terms (79, 81, p. 49 f.). Then this observer would be focally conscious for a short time of an auditory perception of the standard stimulus. This was followed rapidly by a focal kinaesthetic reaction, localized in the eyes, neck and shoulders, which consisted in a muscular strain or tension (79, 80, 81, p. 49 f.). This muscular set remained uninterruptedly and with the same intensity up to the perception of the comparison stimulus. In some cases an auditory image of the first stimulus would come in during this interval but it was usually intermittent and never focal (79, p. 49). The comparison stimulus was then perceived in an auditory fashion for a short time. But an awareness of the muscular strains rapidly became focal and the subject was focally aware either of an increase or decrease of intensity, or that the strains had remained the same. In the former cases (increase or decrease) the difference judgments were formulated. In the latter cases the equality judgment was given. In the case of the equality judgments there was always a verification process in which the entire experience was rehabilitated,—the auditory images of the standard and comparison stimuli followed one another in rapid succession and each accompanied by its muscular reaction. The subject was most focally aware, in this repetition, that the muscular contraction was merely persisting. "I simply retained the muscular set" and "when I got through I was simply aware of this muscular tension" were frequent expressions (80, 81, p. 49 f). Such judgments were always accompanied by unpleasantness. At times this observer would have a visual schema of the process after the judgment had been formulated. There was no apparent effects of practice.

Observer *C*.

The Comparing of Visual Extents

The process of comparing for this subject was always carried on in terms of motor criteria for stimuli of this modality. We are unable to find a single introspection for this observer in which a kinaesthetic criterion was not employed. These kinaesthetic criteria were of two general sorts: 1. The subject would be aware of eye-movements across the standard line with a focal awareness of the intensity of the strains at the end of the movement. Then there would be eye-movements across the comparison line and the subject, on arriving at the end of this line, would either be aware of an increase in these strains, of a decrease, or he would be aware that no change had taken place in the intensity of the strains (82, 83, 84, 86, p. 50 f.). Another form of process was to have the eye-movement over the comparison line of the same extent as that across the standard line, with an awareness of this in terms of strain in the external eye muscles. At the end of such a movement across the comparison line, the subject would find that he was fixating either a point on the line, the end of the line, or a part of the white card beyond the line. 2. The other general form of criterion was in terms of kinaesthesis of accommodation. In this procedure the subject perceived the standard line as a whole with the kinaesthesis of accommodation more local than the actual visual perception. This kinaesthetic experience was held over in an actual motor set and the comparison line was perceived in the presence of this set. Again, in the perception of the comparison line, the visual perception was less focal than the kinaesthetic awareness of an increase or decrease or no change in the intensity of the strains of accommodation. These strains were localized in the interior of the eye, in the region of the lens and cornea (83, 84, 85, 87, 88, p. 50 ff.). In the early stages of practice both criteria of eye-movement and of accommodation might be used successively in a single experience 83, p. 50.). With practice, however, there was a general tendency to use the accommodation type of process more frequently, and in still later practice, the accommodation strains were carried over from the pair of lines exposed before and the subject reported never clearly perceiving the standard line of the next pair. At this stage of practice, a mere glance at the standard line seemed to be sufficient to produce the proper amount of strain in the muscles of accommodation (88, p. 52.). In the case of the equality judgments the process was repeated a number of times and the judgment was made on the basis of an awareness on the part of the subject that "on neither line did the strain let up" (85, p. 51). The fact that, in the equality judgment, the observer had this repetition of the process, while in the perception of difference the process ended at once, was apparently the only distinguishing mark between these two types of judgment.

The Comparing of Auditory Intensities

In the early stages of practice the comparing of sound intensities for this observer was usually carried on in auditory terms. In the fore-period this subject frequently anticipated the experimental situation usually in visual and auditory imaginal terms (89, 90, 91, p. 52 f.). In the later experiences these anticipatory images were not reported. The process in the early stages of practice consisted in a focal perception of the standard stimulus which was usually described as having great duration. Then an auditory image of the same degree of intensity would be present in the interval between the two stimuli. This auditory image of the standard stimulus might persist continuously and without fluctuation of intensity or clearness throughout the entire interval (89, p. 52.), or it might be of a recurrent character (90, p. 52). The second stimulus was perceived in the presence of this auditory image of the norm and apparently the judgment of difference or of similarity in intensity was an immediate perceptual experience. An auditory image of the standard stimulus might come in again as a verification process and was always localized toward the left in a visual spatial manner (90, p. 52).

Very soon, however, this subject employed a kinaesthetic criterion in his comparing of sound intensities. This was described variously as a kinaesthetic "quiver" about the ears (91, p. 52 f.) or a muscular adjustment about the ears and face (92, 93, p. 53). This muscular reaction immediately followed the perception of the first sound and at once became focal in consciousness. This muscular contraction persisted as a set up to the sounding of the second stimulus without change in intensity. Then there was a brief auditory perception of the comparison stimulus. This was of very short duration, however, and the observer reported that very soon he would be aware, focally, of the muscular contractions; and he would be conscious, apparently in an immediate manner, that these strains were continuing or that an increase or a partial relaxation was taking place. At a still later stage of practice, the assumption of this muscular set following the perception of the standard stimulus apparently sank to the physiological level. At this stage of practice, *C.* was merely aware of an auditory perception of the first stimulus, then of an interval reported as unfilled, then of a brief auditory perception of the comparison stimulus. He would then, for the first time, become focally aware of the muscular strains and would be conscious of a decrease, increase or continuation of their intensity (94, p. 53). We are unable to find any differentiating criteria in the process which led to an equality or difference judgment. The difference judgments were perhaps given, to a slight degree, more readily. The equality judgments might be followed by a verification process in which there would be present, in rapid succession, auditory images of the first and second stimuli, localized to the left and right respectively in a visual spatial manner (91, p. 52 f.). At other times such verification was not present (92, p. 53). In the cases in which an equality judgment was given without a verification process, there was always a pause with an awareness of non-focal strains and unpleasantness before the judgment was vocalized (92, p. 53).

The Comparing of Visual Brightnesses

In the early stages of practice, the processes of comparing grays were at times a mere perceptual affair. In this type of process *C.* would either fixate between the two stimuli and perceive both simultaneously in peripheral vision (95, p. 53); or he would perceive one stimulus in foveal vision and the other in peripheral vision (96, p. 53 f.). In such cases the process seemed to be an immediate perceptual experience. More frequently in the early stages and exclusively in the later stages of practice, the process merely consisted in the formation of an absolute judgment of the two stimuli successively or of the comparison stimulus alone. This absolute judgment seemed to be an immediate perception but, in the case of this subject, it was always accompanied or immediately followed by a verbal-motor-auditory image of naming the brightness. In the early stages of practice, this process was followed by relaxation of the general muscular tensions but then the subject perceived the two stimuli alternately several times as a verification process (97, p. 54). With a little more practice the perception of the standard stimulus was of very short duration and the subject reported a mere "glance at it as if the eyes were already moving toward the right hand stimulus" (98, p. 54.). At a later stage of practice, the comparison stimulus was first perceived and absolute judgment of its brightness was at once vocalized although later the subject might perceive the standard stimulus for a short time (99, 100, p. 54). There were very few equality judgments given by *C.* in this series. These few judgments were characterized by great uncertainty and intensive bodily strains and frequently by unpleasantness. There was also in the cases of the equality judgments, an alternation of perception of the two stimuli mixed with the process of perceiving the two together which lasted for the entire time of the exposure (96, p. 53 f.).

Observer *Wd.*

The Comparing of Lifted Weight Stimuli

In the early stages of practice the process of comparing for the subject was based almost solely upon kinaesthetic factors. With the lifting of the first weight the observer was focally aware of kinaesthetic sensations in the wrist, and less focally of similar sensations in the back of the hand and in the forearm (101, 102, 103, p. 54 f.). At times there was a non-focal visual image of the lifting movements (101, p. 54 f.). *Wd.* also frequently made an absolute judgment of the first stimulus, apparently immediately in terms of an awareness of the intensity of the sensations involved in the lifting (103, p. 55). In these cases there was a vocal-motor image of the absolute judgment and also a vocal-motor anticipation of the intensity of the comparison stimulus with manual motor reference toward the right. The interval between the lifting of the standard and comparison stimuli was filled with a kinaesthetic image of the lifting of the standard stimulus. The comparison weight was lifted in the presence of this image and an immediate awareness of greater, same or less intensity of kinaesthesis was made. Then there was frequently a non-focal visual imaginal schema with the standard weight always to the left and the comparison stimulus to the right. In this schema the lighter weight appeared as smaller and lighter in color than the heavier one (102, p. 55.). At this stage of practice *Wd.* frequently called up a kinaesthetic image of the lifting of the standard stimulus when the comparison stimulus was at the top of the lift and stationary, as sort of a verification process. This most frequently occured in the case of the equality judgments. These equality judgments were usually accompanied by an awareness of intensive general bodily strains and unpleasantness.

Soon, however, this observer reported that she believed that the process which held over from the lifting of the first stimulus to the lifting of the comparison weight was really an innervated muscular strain or set and not a true image. The process up to the lifting of the second stimulus was reported as remaining approximately the same. *Wd.* had the awareness of the kinaesthesis of lifting the standard stimulus, localized in hand, wrist and forearm with the wrist most focal, and then the holding of this in an actual set up to the lifting of the comparison stimulus. Again many judgments were made on the basis of an immediate awareness that the intensity of the set had increased or decreased or that it had remained the same (104, 105, 106, 107, p. 55 f.). Also other factors now entered into the process of comparing; for example, the subject reported that the set was not sufficient to lift the comparison weight from the table (104, p. 55 f.). Or again, she reported an awareness of variations in the speed or height of lifting the two weights (105, 107, p. 56).

As practice proceeded the presence of an absolute judgment of the intensity of the sensations required to lift the weights became more frequent, until in time it was a universal feature of all of the experiences. An absolute judgment of the intensity of the sensations for lifting the standard stimulus was frequently followed by an anticipatory judgment, in vocal-motor terms in the way that we have described before, regarding the second weight (105, p. 56). This anticipation was not always present however (106, 107, p. 56). The absolute judgment of the intensity of sensations used in the lifting was always mediated, or at least accompanied by vocal-motor-auditory imagery of naming it. In time this developed into a well defined verbal schema of seven categories. These were grouped about an average intensity with three categories on each side of the average (106, p. 56). Hence in the later stages of practice, the process for this observer consisted in either the awareness of a change or no change in the motor set carried over from the lifting of the standard to the comparison stimulus, plus the judging of the intensity of the sensations involved in the lifting of each weight in absolute terms, in accordance with this verbal schema of seven categories.

Observer *F*.

The Comparing of Lifted Weight Stimuli

The process of comparing the intensities of lifted weights was exceedingly simple and relatively uniform for this observer. In the early stages he reported that each stimulus was grasped with just sufficient strength to keep it from slipping out of the fingers. The observer was then aware focally of a tactual sensation on the ends of the fingers, with that on the end of the third finger most focal. A true tactual image of the lifting of the first stimulus was held over in consciousness up to the lifting of the comparison weight. The subject then reported that an immediate judgment was made between the intensities of the tactual image of the lifting of the first weight and the actual tactual sensations involved in the lifting of the second weight (108, 109, 110, 111, 112, 113, p. 57 f.). Also an absolute judgment would be made regarding the intensity of each stimulus. This absolute judgment was described as a mere verbal characterization of the immediately perceived intensity of the tactual sensations, with also a visualization of the weight (109, 111, p. 51). It later turned out, when we were nearly halfway through the experimental series, that this observer had been employing a well defined visual schema of three categories of increasing and decreasing intensity on each side of a medium intensity (112, p. 57 f.). Later (113, p. 58) we obtained a description of this visual schema which consisted in a visual image of seven vague grey spots,—that spot representing the medium intensity being directly in front of the observer with those representing the lighter intensities to the left and the heavier to the right. There was imagery of fixation of one or another of the parts of the schema corresponding to the intensity of the tactual sensations and this part of the schema then appeared to be more clear than the rest of the spots. This sort of process was frequently accompanied by a verbal characterization which immediately followed the tactual perception. As practice proceeded more emphasis was laid upon this visual schema but this subject never reported a mere judging in absolute terms; as the tactual image of the lifting of the standard stimulus was always carried over to the lifting of the comparison weight. There was no apparent difference in the type of process which led to a difference or to an equality judgment.

Observer *P.*

The Comparing of Lifted Weight Stimuli

The process of comparing lifted weights remained practically unchanged for all stages of practice for this subject. Kinaesthetic and tactual experiences were reported solely as the criteria for the comparison. The tactual sensations on the ends of the fingers never occurred alone in consciousness but were always in connection with the kinaesthetic sensations of the lifting (115, p. 58.). After a short period of practice this subject ceased to report tactual sensations at all. Indeed he reported (116, p. 58 f.) that the tactual sensations were no longer a variable factor as each weight was grasped with the same force. The kinaesthetic sensations were reported as being localized in the hand, wrist and forearm (114, 115, 116, 117, 118, 119, p. 58 f.), and each of these parts might at times be more focal than the others. After practice there was a tendency for the muscular sensations in the forearm to be the more focal. The process, as described, consisted in a tactual and kinaesthetic awareness of the lifting of the first weight. An image of this was held over until the comparison stimulus was lifted and the subject was then aware of the intensity of the sensations for the lifting of this weight; and a direct comparison was made between the intensity of these sensations and the intensity of the image of the lifting of the standard stimulus which had just preceded (114, 115, 116, 118, 119, p. 58 f.). At other times the subject reported being aware that the comparison stimulus, lifted in the presence of this image, was lifted more or less rapidly (115, 117, 118, p. 58 f.). This subject frequently spoke of lfting the two stimuli "with a certain swing" or force (116, 117, 118, p. 58 f.). Absolute judgments were not frequently present and were apparently immediate awarenesses of tactual and kinaesthetic intensity (115, p. 58). The processes of comparing which led to the equality judgments was quite as rapid as those which led to judgments of difference. This observer reported that the equality judgments were formulated on the basis of an ability to discover a difference between the intensity of the sensations of lifting the second stimulus and the image of the lifting of the standard; or an inability to discover any difference in the rate of lifting. This observer reported (119, p. 59) that he had definitely adopted an attitude of looking for a difference and his inability to discover a difference was always accompanied by unpleasantness.

Observer *B.*

It will be remembered that Observer *B.* was not so highly trained in introspection as were the other subjects whose processes we have discussed up to this time. Indeed, we employed *B,* as a subject more for the training which she would obtain rather than for the insight into our problem which we hoped to obtain from her. Her introspections are by no means complete analyses and descriptions of her mental processes but still they are capable of giving some idea of what went on in this observer's consciousness.

The Comparing of Visual Extents

In the early stages of practice this subject reported an awareness of eye-movement across the standard and then across the comparison line. After the second line had been perceived, a visual image of the standard line was usually present in consciousness (120, 122, 123, 124, p. 59 ff.). This visual image was projected just above the comparison line with the left end of the image and the actual line in the same positions. The observer was then aware that the right end of the visual image extended exactly as far as the end of the comparison line, further, or not so far. The image of the standard line and the perception of the comparison line were in consciousness simultaneously and the judgment in verbal terms followed immediately.

Even in the earlier experiences, however, this subject noted kinaesthetic processes. She was aware of eye-movements across the lines and spoke of a comparison of kinaesthetic images which she was unable to describe (120, p. 59 f.). In the later experiences this observer reported a "hitch" in the eye-movement as she was examining the comparison line and, for the longer lines, the eye-movement halted before the right end of the comparison line had been reached (124, 125, p. 60 f.).

When a visual image was employed, the equality judgments were as rapid and apparently as immediate as were the difference judgments (122, 123, p. 60). If the process did not consist of the employment of a visual image of the standard line, there resulted a more or less lengthy process with verification, strains and always unpleasantness (121, p. 60).

The Comparing of Auditory Intensities

This subject at times reported a vague visual image of the experimental situation connected with the perception of the two stimuli (128, p. 61). She also at times reported an auditory image of the standard stimulus, but this invariably tailed off and had practically disappeared before the sounding of the comparison stimulus (126, p. 61). For most of the experiences no auditory image of the first stimulus was reported and, at times indeed, this observer stated with a great deal of assurance that no auditory image was present (128, p. 61). In every experience a muscular reaction was noted as being present in consciousness immediately after the perception of the standard stimulus (126, 127, 128, 129, p. 61 f.). This was invariably localized in the mouth, tongue, head and body. A similar reaction of a kinaesthetic sort was noted after the perception of the comparison stimulus and an awareness of the degree of tension was the basis for the judgment. Later this subject reported that the tensions of this first reaction carried over to the second stimulus and that there was then an immediate perceptual awareness that the intensity of these kinaesthetic strains had increased, decreased or had not changed (129, p. 62).

The Comparing of Visual Brightnesses

In the early stages of practice this observer showed a very simple sort of process for the comparing of visual brightnesses.

The process was a purely perceptual affair as far as we can determine from the observations reported. The fixation was on the card between the two stimuli and the inner edges of both the standard and comparison grays were perceived simultaneously. The judgment was given at once and this was usually followed by rapid eye-movements and a hasty perception of the two stimuli separately (130, 131, 132, p. 62). If no judgment was formulated on the basis of the perception of the two stimuli simultaneously, there was usually a rapid perceptual alternation of them a number of times and this was usually followed by a return of fixation between them and a perception of the two simultaneously. Such processes were usually accompanied by a great deal of verbal-motor characterization and usually led to an equality judgment (131, p. 62).

Later, as a result of practice, the process changed. There was now a focal perception of the comparison gray with the standard gray perceived more or less clearly in peripheral vision and the process seemed to consist merely in the immediate formulation of an absolute judgment regarding the brightness of the comparison gray (133, 134, p. 62 f.). This was frequently followed by a perception of the standard stimulus as a sort of verification process.

Observer *T.*

It will be remembered that Observer *T.* was not so highly trained in introspection as were the other subjects whose processes we have discussed with the exception of the other relatively untrained Observer *B.* We employed *T.* as a subject for the same reasons for which we employed *B.*,—namely, for the practice in introspection which he would obtain during the experimentation rather than for any insight into our problem which we hoped to obtain from him. This observer's introspections were by no means complete descriptions of his mental processes. Indeed his introspective descriptions of the process of comparing visual extents were so incomplete that we have eliminated a discussion of them from this account of our experiment. Observer *T.* did, however, on the basis of more training, give a reasonably adequate report of his mental processes in the comparing of sound intensities, although we believe that these are still very incomplete descriptions of his mental processes.

The Comparing of Auditory Intensities

At no time during the experimentation did this observer report the presence of an auditory image in consciousness. In the early stages he reported that he was aware of an inhalation immediately following his perception of the standard stimulus which was held until the perception of the comparison stimulus. Immediately following the perception of the comparison stimulus he was aware of a further inhalation, of an exhalation or of a mere continuation without change, which led to the formulation of judgments of the three different categories respectively of greater, less and equal. These changes of degree of inhalation were reported to have been in consciousness in terms of pressure sensations in the chest (135, 136, p. 63). As experimentation continued this breathing criterion was replaced by one of a more purely kinaesthetic sort (137, 138, p. 63). The subject now reported an awareness of kinaesthetic strains, localized in the body, neck and head, immediately following his perception of the standard sound. These strains were then held in a definite muscular set up to the perception of the second sound. With the perception of the comparison stimulus, the subject was aware, apparently in immediate terms, of an increase, decrease or of no change in this muscular set. Verification processes occurred at times and these always consisted in a rehabilitation of the two strained conditions without, apparently, any mediating auditory imagery (137, p. 63). Very few equality judgments were given by this observer in the auditory series of experiments.

3. *The Structural Components of Comparing*

In the preceding section we have given outline summaries of the process of comparing for each of our experimental arrangements and for each of our subjects. Various stages in the mechanization of the process were noted. A study of these summaries indicates the fact that the structural basis of this process rests upon the three widely accepted mental elements—sensation, image and affection. Of these the affective element may be dismissed at the outset. Affection never seemed to be an essential part of the process of comparing. Some affective processes were reported rather infrequently, but almost invariably when they were present they came into consciousness after the judgment had been formulated and seemed to be closely related, if not an integral part of the certainty or uncertainty, the ease or difficulty, of the formation of the judgment.

With regard to the other structural components of the process of comparing there seems to be a difference in the quality and complexity of these processes at the different stages of practice. Certain generalizations can be made which seem to be true for all of our subjects and for all modalities of stimulation which we employed. The content seems to be very much foreshortened and mechanized as a result of the progressive practice which the subject obtained during the experimentation. This is seen in a decided decrease in the amount of content present for any single experience at the later stages of practice. Furthermore, there seems to be a great prevalence of imagery for the early experiences while in the later stages the emphasis is more strongly on sensation than on image.

As to the modalities of the sensations and images reported by the observers there is, of course, a certain amount of divergence because of the differences in imaginal type. But perhaps the one great outstanding feature of this study is the prevalence and apparent importance of the kinaesthetic experience for the formation of judgments of this sort.[1] For only one observer (*F.*) in the experiments with lifted weights, auditory and line stimuli did the kinaesthetic experience fail to play an important part in the process of comparing. This subject made his comparisons of lifted weight stimuli at first largely in terms of tactual ex-

[1] By kinaesthetic *experience* we include both sensation and imagery of this modality without making the exact differentiation between the two. We shall have something to say later in this paper regarding the significance of kinaesthesis in the formation of comparison judgments of this sort. At the present time we merely wish to emphasize the fact of its frequent, indeed almost invariable, presence.

periences and later a visual schema played a very essential part. We must also qualify our former statement by eliminating the entire series of the comparing of grays. This series was really unfruitful in a sense because the two stimuli were so close together that the subjects could perceive a considerable portion of both stimuli simultaneously in foveal vision. The comparison here was largely a direct and immediate perceptual experience.

Let us now consider the modalities of imagery and sensations reported by each of our observers. Observer *W.* in the lifted weight experiments reported, in the early stages of practice, the presence of many different modalities of sensation and image, viz: visual, kinaesthetic and tactual. As practice continued the visualization of the process dropped out of consciousness as did also the tactual experience. This subject reported at this later stage for lifted weights, practically only the presence of kinaesthetic factors. In the case of the judgment of visual extents, this subject at first employed both visual and kinaesthetic experiences in the formation of the judgment. The kinaesthesis was localized either in the external eye-muscles or in the muscles which have to do with visual accommodation. As practice proceeded the visual (retinal) elements and the kinaesthesis of eye-movement were no longer reported, and the kinaesthesis of accommodation seemed alone to be present. This subject reported in the auditory series, that in the early stages, auditory, visual and kinaesthetic factors were present. This kinaesthesis was widespread and included vocal-motor experiences as well as kinaesthesis of parts of the trunk, neck and face. With practice the visual and auditory experiences were less frequently reported and the kinaesthesis became much less extended.

Observer *Fs.* in the early stages of the lifted weight experiment, reported visual and kinaesthetic experiences. Practice seemed to make but little change for this subject, although there was a tendency for the visual elements to be less frequently reported. For the judgments of lengths of lines visual and kinaesthetic experiences were again reported and in this series, also, practice seemed to make little if any change in the process. *Fs'* protocols indicate little change with practice in the content for judging sound intensities. Auditory, visual, vocal-motor and general kinaesthetic experiences were reported. This observer's judgments of the comparing of grays were carried on by visual perceptual experiences, with some slight kinaesthesis of change of fixation and vocal-motor experiences.

Observer *O.* reported, in the series with the comparing of lines, only visual perceptual and kinaesthetic processes at all stages of practice. In the comparing of sound intensities, auditory perceptual, vocal-motor and general kinaesthetic experiences about the head and body were reported. For the comparing of grays, visual perceptual and vocal-motor experiences were alone reported by this observer.

For Observer *S.*, in the early stages of the comparing of lines, visual experiences, both perceptual and imaginal,—were reported, as were also ocular motor and manual motor experiences. The processes at this stage were very rich in content for this observer. Practice seemed to have little effect except that there was a tendency for the conscious content tc become less complex. The content for this observer in the process of comparing auditory stimuli consisted of visual imaginal, auditory and kinaesthetic experiences of which the latter were the most frequent.

Observer *C.* reported the presence of kinaesthetic experiences invariably in his judgment of the length of lines. This kinaesthesis was localized largely in the external eye-muscles and in the muscles of visual accommodation. Visual perceptions were, of course, noted by this observer in this series. In the comparing of sound intensities, this observer reported the presence in consciousness of auditory, visual and kinaesthetic processes. For the comparing of grays Observer *C.* reported only for the presence of visual perceptual, vocal-motor and ocular-motor experiences.

In the process of comparing lifted weight stimuli, Observer *Wd.* reported the presence of kinaesthetic experiences and of visual imagery. There seems to be a distinct change in her case with progressive practice from a frequent presence of kinaesthetic imagery to actual kinaesthetic sensations.

Observer *F.* reported very different sorts of content for the comparing of lifted weight stimuli than do the other subjects.

He seldom reported any kinaesthetic experiences. The modalities of content invariably present were the tactual,—both sensation and image,—vocal-motor and visual imaginal. It was this subject who worked out a very complete and rather complicated visual imaginal schema in his processes.

Observer *B.*, in the series of judgment of the length of lines, reported visual and kinaesthetic experiences alone. In the auditory series, kinaesthetic and auditory and infrequently visual experiences were reported. For the series of grays visual perceptual and vocal-motor experiences were reported.

In the auditory series, Observer *T.* reported the presence in consciousness of auditory perceptions but never of an auditory image. Kinaesthetic experiences were invariably reported by this subject in this series.

In summary, then, we find that the structural components of the process of comparing which we had under investigation comprise the three usually accepted mental elements,—namely, sensation, image and affection and ***no others***. We failed to find any new elements beside these three. In this respect our results are in complete accord with those of Marbe.[1] This author set himself the definite problem of finding a structural criterion between judgment and a simple association of ideas. On the basis of the protocols of his observers, he reports that his experiments have failed; that there is no evidence that such a structural difference exists. Marbe then continues his discussion along logical lines and asserts that the intention of the observer is the distinguishing characteristic. In our particular problem we were interested in only a very small part of the general problem of judgment, hence we need not discuss Marbe's logical contributions. We merely wish to point out that our experimental results are entirely in accord with his, inasmuch as we both found that the process is present to consciousness structurally in terms of sensations, images and affections. Of these, the affections seem to be relatively unimportant and are present, apparently, only as part of the experience of ease or

[1] K. Marbe. ***Experimentell-psychologische Untersuchungen über das Urteil.*** Leipzig, 1901. Pp. iv+103.

difficulty of the formation of the judgment of comparison. The image is present almost invariably in the earlier stages of practice and may be of several modalities, dependent partially on the nature of the stimulus, and partially on the imaginal type of the observer. Visual, kinaesthetic, auditory and tactual concrete and verbal-motor images were reported by our observers. Sensations were, of course, always reported in every experience. If nothing else there was the perception of the stimuli. But, with later practice, the kinaesthetic sensation played an important rôle in the comparison consciousness. Indeed we wish again to emphasize the frequency of occurrence of the kinaesthetic sensation and the kinaesthetic image in these processes, no matter what the modality of the stimuli under consideration nor the imaginal type of the observer.

4. *The attributive pattern of the process of comparing which led to the formation of the difference judgments*

In the following discussion we shall employ the term function in the sense in which it is used in physiology. In the section on the structural components of comparing we discussed the *content* of consciousness during this process. We treated of the elemental psychic processes which were disclosed by the introspections. We treated also in that section of the qualitative attributes of these contents because we found it very difficult to divorce the discussion of this attributive feature from that of the elements themselves. In the present section we shall treat of *how* these elemental processes were present in consciousness, namely, of the intensity, clearness, durative and spatial relations between them. We shall first discuss those conscious processes which led to the formation of the difference judgments, and then in the next section we shall take up the processes which led to the formation of the equality judgments.

The comparing of lifted weight stimuli

The process of comparing lifted weight stimuli was more or less similar for most of our subjects. It will be remembered that in this series, the space error was eliminated by the turning top table, while the time error was in the first order, *i.e.* the standard weight was lifted first and the comparison weight second. In the early stages of practice, the subjects reported that there was first a clear and focal perception of the standard stimulus. In this initial perception the kinaesthetic sensations localized in the hand, wrist and forearm were usually most focal. This was true for Observers *W.*, *Fs.*, *Wd.* and *P.* For Observers *P.* and *F.*, the tactual sensations localized on the ends of the fingers were also very vivid in this initial perception of the first weight. This was particularly true for Observer *F.*, who made it the principal criterion of his judgment. Several subjects report that, accompanying this perception, there were other processes which frequently developed into a high degree of clearness. For Observers *W.*, *Fs.*, *Wd.* and *F.*, there was frequently a visualization of the process, sometimes merely of the hand movements; at other times of the weight itself. In the latter case, the visualization of the stimulus was in the nature of an absolute judgment regarding its intensity,—the heavy weights being visualized as large or dark in color and the light weights being visualized as light in color or small. Another form of absolute judgment of the intensity of the first weight consisted in a verbal motor process following the initial perception, as was true in the case of Observers *Wd.*, *F.* and infrequently for *P.*

Following this initial perception, and during the lifting of the empty hand before the grasping of the comparison stimulus, all of the subjects reported the presence of an imaginal representation of the first weight, in the early stages of practice. This imaginal representation was reported as being present in various modalities by Observer *W.*,—namely, tactual localized on the finger tips, kinaesthetic in the hand, wrist and forearm, and visual. The image, in the case of this observer, remained relatively constant throughout this period, but different modalities might be focal in different experiences. Observer *Fs.* reported that this interval was filled by a kinaesthetic image of the lifting of the first weight localized in the arm, hand, and wrist, with frequently a non-focal visualization of the lifting of this stimulus. She also reported that this kinaesthetic image was frequently reinforced by actual innervation. Observer *Wd.* reported the presence of a kinaesthetic image localized in hand, arm and wrist during the interval between the lifting of the standard and comparison stimuli. Observer *P.* also reported a continuous tactual and kinaesthetic image of the standard weight during the empty interval. In this image of the tactual components soon became constant from one experience to another, and also became non-focal. The kinaesthetic image localized in the forearm was usually much more vivid than those in the wrist and hand. There was also present infrequently for some of the subjects, during this interval, an anticipation of the judgment. In every case this would follow an absolute judgment of the intensity of the standard stimulus if that judgment were, subjectively, extremely heavy or extremely light. The anticipation was always in the opposite direction, *i.e.* an anticipation that the second weight would be heavier if the first weight had been light, and *vice versa.* Observer *Wd.* reported this experience more clearly and more frequently than any of the other subjects. For her, the process consisted in a vocal-motor image of the word "heavier" or "lighter" with a motor imaginal reference to the right,—the direction from which the second stimulus would be presented. The case of Observer *F.* will be discussed later.

Although all of the observers, in this early stage of practice, report the presence of imaginal content from the time of replacing the first weight up to the lifting of the second, they are all unanimous in stating that this imaginal representation of the standard stimulus dropped out of consciousness immediately upon the perception of the lifting of the second weight. In other words, the imaginal representation of the first stimulus and the immediate perception of the second stimulus were never actually simultaneously present in consciousness. In the early stages of practice, Observer *W.* reported that the image of the first weight remained in consciousness just up to the perception of the comparison stimulus, then the kinaesthetic sensations involved in the lifting of this second stimulus became focal and the judgment usually followed immediately. This judgment of the relative intensity of sensation and image usually seemed to be an immediate experience, and *W*. reported that it was made on an attributive basis. Following the formation of the judgment, there was always a visualization of the situation, in which the standard weight was always projected toward the left and the comparison weight toward the right. The intensity relations were present, in this visual image, in terms of variations of the size and color of the images of the weights or in the height which they appeared to be from the table.

For Observer *Fs.*, the process at times was essentially the same as that just described. She reported that the imaginal representation of the first weight remained only up to the perception of the second weight. The kinaesthetic sensations involved in the lifting of the second weight then became focal and the judgment was made immediately apparently on an attributive basis of intensity. The judgment was at once visualized. At other times this subject reported a different type of procedure. The imaginal representation of the lifting of the first weight remained, as before, just up to the lifting of the comparison weight, and then, again, the kinaesthetic sensations involved in the lifting of this stimulus became focal. This subject reported that the judgment was made on the basis of variations of the speed or height of the second lift as compared with the first. In this procedure there was always a mediating visual image of the relation, which was focal before the formation of the judgment. Immediately upon the formation of the judgment this was vocalized apparently without pre-imaging. For this observer, there was always a non-focal visualization of the situation following the formation of the judgment; in which image, the standard weight was always projected toward the left and the comparison weight to the right. The image of the lighter of the two weights appeared as more transparent or "less solid" than the heavier stimulus.

Observer *Wd.* reported exactly the same sort of procedure which we observed for *W.* and *Fs.*,—namely, a retention of the image of the lifting of the first weight up to the perception of the second. The kinaesthetic sensations of this lifting then became focal and the judgment was made at once on the basis of an immediate awareness of the relative intensity of the image and perception, although these were never exactly simultaneously present in consciousness. At times a visualization of the experimental situation occurred after the formation of the judgment; this visual image being practically similar, in form, to those already discussed for *W.* and *Fs.* The precedures reported by Observer *P.* did not vary essentially from those described by *Fs.* The image of the lifting of the first weight remained up to the perception of the kinaesthesis involved in the lifting of the second stimulus; which latter then became focal. The two procedures of an immediate awareness of relative intensity of the image and perception, or an awareness of differences in the speed of the lifts were both reported. This subject, however, did not report any mediating visual imagery in the second type of judgment, but declared that it was an immediate awareness.

At a later stage of practice in the lifted weight experiments, the attributive pattern was changed for most of our observers to a very considerable extent. Observer *W.* reported, for this later stage of practice, the following changes. In the first place the visualization of the processes of the lifting of the two weights tended to drop out entirely, and even the visualization following the judgment tended to become less intensive and vivid. This subject reported that, following the perception of the standard stimulus, instead of an imaginal representation of this lifting which persisted up to the lifting of the second weight, that an actual innervation or a sort of tetanus of the muscles of the forearm was now present. This persisted up to the second lifting and, indeed, the comparison weight was lifted in the presence of this actual muscular set. The subject then reported that he was aware of a change in either the speed or height of the second lifting as compared with this muscular set. This was described by the observer as an immediate perceptual experience which led to a perfectly mechanical verbalization of the judgment, without the mediating presence of a visual image. This subject also reported that affective processes only came into consciousness after the formation of the judgment and then they seemed to be bound up with the degree of subjective assurance; unpleasantness being present with the more doubtful judgments and pleasantness being present with the very certain judgments.

The processes described by Observer *Fs.* showed little change as a result of practice. In her case, also, the visualization of the process and of the judgment tended to drop out of consciousness, and when present, they were less focal than before. The kinaesthetic criteria seemed to be the same as those reported at the earlier stage of practice except that the procedure of judging the speed and height of the lift rather than that of comparing the intensity of the kinaesthetic sensations involved became more and more frequent. It will be remembered that this observer reported from the first the presence of actual innervation of the muscles of the forearm during the period between the replacing of the first stimulus and the lifting of the second. Also the vocalization of the judgment became exceedingly automatic for this subject as a result of practice.

Observer *Wd.*, after considerable practice, reported that there was actual innervation of the muscles of the forearm during the period between the two liftings, rather than an image of the kinaesthesis of the lifting of the standard stimulus. The criteria of judgment, both of differences in intensity of this muscular set and the kinaesthetic sensations involved in the lifting of the second weight; and also of differences in the speed and height of the two lifts were still employed and reported as immediate awarenesses. These processes were no longer mediated by visual or other images. This subject also reported, at times, in the case of the heavier judgments, that the muscular set was not sufficient to lift the second weight from the table. Observer *Wd.* also reported with further practice the universal presence of an absolute judgment regarding the intensity of the first weight, either with or without an anticipation of the comparison stimulus. Verbal motor imaginal characterizations were always present in these absolute judgments and later, there developed a well defined verbal schema of seven categories, ranging from "very light" to "very heavy," which functioned in the formation of the absolute judgment of the standard stimulus. Hence, for this subject at the end of practice, we find the presence of the actual muscular set plus the absolute judgment in every experience.

The processes described by Observer *P*. showed practically no change as a result of practice. He continued to speak of a tactual-kinaesthetic image of the lifting of the first weight persisting up to the lifting of the second. In no place did he speak of an actually innervated muscular set during this period. We believe, however, that this actual set was present even though it was not reported. For example, as practice continued, this subject more and more strongly emphasized the muscular image in the forearm, and declared that the tactual sensations localized in the fingers and the kinaesthetic processes localized in the hand and wrist became less and less clear and vivid. He also reported that he approached both of the weights with a certain "swing" which would indicate just such a motor preparation. He further stated that he judged by means of the height of the lift. Hence we believe that we are justified in assuming the presence of an actually innervated muscular set in the case of this observer, present during the period between the two liftings, although it was never actually explicitly reported. We believe that we are justified in assuming the presence of this set, inasmuch as the processes described by this observer as identical to those reported by our other observers with whom the set was present.

We have left until now a description of Observer *F's*. procedure in the lifted weight experiments because the type and behavior of his content was so different from that of the other observers. This subject reported that each weight was grasped with just enough force to keep it from slipping through the fingers. The focal thing in consciousness during the lifting of the standard stimulus was the intensity of the tactual sensations on the tips of the fingers, particularly the third. In the early stages of practice, a tactual image of this lifting remained focal in consciousness to the lifting of the second weight. But this observer also reported that the image of the lifting of the first weight and the actual sensations of the lifting of the second were never actually simultaneously present to consciousness. Absolute judgments were frequent also in the early stages of practice. It turned out later that this subject had developed a verbal-motor and visual schema of seven categories of absolute intensity. This visual schema was localized in front of the subject with the lightest weight to the extreme left and the heaviest to the extreme right. When the standard stimulus was lifted, the tactual sensations would be focal in consciousness for a moment and then one or another of the seven spots in the visual schema would become more clear, along with a vocal-motor image of the name of that category. The same sort of an absolute judgment would be made after the tactual perception of the second weight had been focal, in terms both of the verbal motor naming and of the clearing up of some part of the visual schema. The judgment in this case was in the nature of a logical inference from the two cleared up parts of the schema; but this latter process was rapid, very mechanical and seemed to lead at once to the vocalization of the judgment. Practice had very little effect upon the processes of this subject except that he reported greater emphasis on the absolute judgment and the use of the visual imaginal schema; but the comparing of the tactual image of the lifting of the first weight with the tactual perception of the second was never lost although it became less focal.

In general, then, for Observers *W.*, *Fs.*, *Wd.*, and *P.*, we note two distinct types of process in the comparing of lifted weight stimuli. In the early stages of practice, the process consisted essentially in the comparing of a tactual-kinaesthetic image of the first weight with the intensity of the kinaesthetic sensations aroused by the lifting of the second weight. The image and the sensations were never exactly simultaneously present in consciousness. Also visualization of the process was frequent for most observers, at this stage of practice. The absolute judgments were more or less present from the beginning of experimentation and appeared to be, more or less, an immediate perceptual process. At a later stage of practice, the visualization tended to drop out and, when present, became less clear and vivid. The absolute judgments tended to increase in frequency. Aside from this, the general conscious content was largely changed. The subjects now reported an actually innervated muscular set or preparation, described by some subjects as an actual "muscular tetanus" in the muscles of the forearm, following the lifting of the standard weight. This continued during the interval between the liftings, and the comparison stimulus was lifted in the presence of this set. The judgment of difference then consisted largely in the immediate awareness that the hand had gone up higher or not so high, more rapidly or more slowly, as the case might be. This was apparently again an immediate perceptual experience;—at least we were unable to obtain any descriptive analysis of this part of the process. Observer *F.* presents another sort of picture. He started with a process which consisted in a focal awareness of a tactual image of the first weight up to the perception of the second stimulus. Then, after practice he had more and more focally the formation of an absolute judgment on each of the stimuli. Practice, for him, consisted largely in the definatizing of a visual-verbal-motor imaginal schema of seven categories of absolute judgments of the intensities of the tactual sensations.

The Comparing of Visual Extents

In the series in which lines were used as our materials, it will be remembered that the two stimuli were presented simultaneously with the space errors in the first order, *i.e.* with the standard line always to the left. In this series also, several types of processes mark different stages of practice for most of our subjects.

In general, for the early stages of practice, the process consisted in a clear perception of the standard line; a carrying over of an image of this line to the other stimulus; a perception of this second line and then the judgment. One might expect, with the presentation of such stimuli, that the imaginal representation of the first line which was compared with the perception of the second, would have been a visual image. This was infrequently the case however.

Observer *W.* at times employed a visual image of the standard line which was projected just above the comparison stimulus and, in the case of a difference judgment, either extended beyond the comparison line or not so far. In this case the image of the standard line and the perception of the comparison line were simultaneously present in consciousness. This was also true in the case of another procedure employed by *W*. In this case he would fixate directly between the two lines and would then become aware that the extreme end of one line would appear less clear than the extreme end of the other, and would therefore be judged longer. Hence the judgment of difference in this case never got beyond the perceptual level. Other types of processes were also employed by *W*. in these early stages of practice. He reported a focal awareness of eye movement from left to right across the standard line and then a similar movement across the comparison line, and an immediate judgment of greater or less intensity of the kinaesthetic sensations at the end of the second movement. Similar perceptual procedures of apprehending the two lines were followed by a judgment in terms of the duration of the eye movements, in a manner which was either immediate and performed on an attributive basis or else was incompletely described by the subject. Still another procedure was employed by Observer *W*. in this early stage of practice. This was to fixate the standard line alone until the ends of this line became clear, but with the strains of accommodation in focal consciousness. Then there would be a shift of eye fixation to the other line and then the subject would be aware of an increase or decrease in the intensity of these strains of accommodation while the visual perception of the comparison line was clearing up. The awareness of the change of intensity of these strains and of the direction of this change led at once to the vocalization of the difference judgment.

In the early stages of practice, Observer *Fs*. reported only one type of procedure. She would be aware of eye movement across the standard line from left to right. She was focally aware of the visual perception of the line, however, rather than of the kinaesthesis of the eye movements. Then there was an awareness of a sudden and rapid shift of fixation to the comparison line and then an awareness of eye movement across this line. Again the focal content in consciousness was the visual perception of the line rather than the kinaesthesis of the eye movement. At the end of this movement, in the case of a difference judgment, *Fs*. reported that she was either focally aware of a portion of the right-hand end of this line, in the case of a "greater" judgment or that she was focally perceptually aware of a small section of the white card just beyond the right-hand end of this line, in the case of a "shorter" judgment. It will be noted that this subject, in this series and in the series with grays, always reported changes in eye fixation in terms of a change in the visual perceptual field rather than in terms of kinaesthetic sensations in the eye muscles.

Observer *O.* reported, in the early stages of practice in this series, a perception, several times repeated, of the standard line. In this perception the kinaesthetic sensations of eye movement were always focal as compared with the visual perception of the line itself. This was particularly true on reaching the ends of the line as at that time there was a marked rise in focality and clearness of the kinaesthetic sensations. He then reported a non-focal awareness of the kinaesthesis of head movement to the second line. Then he would be focally aware of the kinaesthetic sensations of the external eye muscles as the fixation moved across this line with a less clear visual perceptual awareness of the line. Suddenly he would be aware of a stopping of this eye movement, of a "muscular hitch" as he described it, and then of a focal visual perception either of a portion of the end of the line or of a portion of the white card beyond the line. These obviously led to the two difference judgments respectively of "greater" or "less." Then the vocalization followed at once and very automatically.

In the early stages of practice, Observer *S.* reported a great number of different kinds of processes. Each sort would be employed almost always exclusively in a single experience, however. Two sorts of visual comparisons were made, in both of which there were an immediate and simultaneous awareness of a visual representation of the first line and a visual perception of the second. In the first type of procedure, there was a rapid perceptual alteration of the two lines until finally one remained in focal consciousness. In every case of this sort it was the longer line which was present and a visual image of a short perpendicular line would be projected near the right-hand end of this stimulus,—marking off the extent to which this line was longer than the other. At other times a visual image of the standard stimulus would be superimposed upon the comparison line and would either extend beyond it or not quite reach the end of it, in the case of the difference judgments. This subject also reported at least three types of experience in which kinaesthetic factors played a very considerable part. Observer *S.* would be focally aware of the intensity of the kinaesthesis of eye movements in moving his fixation from left to right across the standard line. Then he would be aware of a rapid shift of eye movement to the comparison line, largely in terms of a change of the visual perceptual field, and then focally aware of the intensity of the eye movements across this line. He would then have an awareness of an increase or decrease of the intensity of the strains in the external eye muscles as his fixation reached the end of this second line, which led to the formulation of the two difference judgments. Another form of kinaesthetic process, which however was never completely analysed by this subject, consisted in a fixation between the two lines and a non-focal visual perception of both simultaneously. Then there would develop focally an awareness of strains on one side of the body,—the side always toward the longer line. Still another rather curious motor procedure was for this subject to have a rather vivid visual perception of the standard line accompanied by a more vivid awareness of a kinaesthetic image, localized in the hand and fingers, as if he were spreading the thumb and forefinger a distance equal to the line. This was then carried over in an actual manual motor set and the comparison line was perceived visually. Much more clear, in the case of a difference judgment, than the actual visual perception of this second line was a kinaesthetic awareness of an increase or decrease in this manual motor set. Several procedures involving absolute judgments were also employed. This observer reported frequently an illusion which seemed to form the basis of his judgment. If a line was judged to be absolutely long, *S's.* visual perception of that line would appear to be narrow and light in shade; if the line was judged short in absolute terms, it would appear to be broad and very black. We rather suspect that the illusion in perception led to the formation of the absolute judgment rather than the reverse. Also at a very early stage of practice this observer reported a type of process which was characteristic of some of our subjects at their last stage of development. In this procedure, *S.* reported that he was aware of carrying over of a muscular set or strain of a certain intensity from the comparison line of the pair before. He then clearly perceived the comparison line of this pair and, in the case of the difference judgments, was at once aware of an increase or decrease of the intensity of this strain, and this at once led to the vocalization of the judgments 'greater' and 'less' respectively. In this procedure the judgment was formulated without any perception of the standard line.

In the early stages of practice with this sort of stimuli, Observer *C.*, on the other hand, invariably employed kinaesthetic criteria. Three general types of procedure were employed. In the first of these, this observer would be aware of an eye movement across the standard line from left to right with a great increase in clearness of the intensity of the strains of the external muscles of the eye when the fixation reached the right-hand end of this line. Then he was aware of a change of fixation to the comparison line,—largely in terms of a change of the visual perceptual field. This line would also be explored from left to right with a great increase of clearness of the intensity of the strains on reaching the right-hand end of this line. This observer reported that the awareness that the intensity of the strains was greater or less at the end of the second excursion as compared with the first was an immediate experience, and the vocalization occurred at once. Another type of procedure employed by this observer was similar to that described for subjects *W.* and *Fs.*, in which the eye made the same excursion across the second line as it had across the first and the subject, in the case of the difference judgments, discovered that at the end of the second excursion he was clearly aware in visual perceptual terms either of a part of the line or of the white card beyond the line. Also changes in accommodation were employed such as we have described in the case of Observer *W.* In this case the standard line would be fixated without eye movement and would be clearly perceived as a whole.

More vivid than the actual visual perception would be the awareness of the intensity of the strains of the muscles of accommodation. These strains were reported as being held in an actual muscular set and carried over, by a change in fixation, to the comparison line. Then *C.* would be focally aware of an increase or of a decrease in the intensity of these strains, as the visual perception of this line was clearing up. In the early stages of practice for this observer, all three types of processes were used indiscriminately and several kinds would often be reported as being used in a single experience.

Finally in this series of visual stimuli, Observer *B.* reported both visual and kinaesthetic types of processes. She employed an immediate and simultaneous comparison of a visual image of the standard line with a perception of the comparison line, almost identical to that described for Observer *S.* Also two sorts of kinaesthetic processes were reported. In the first there was a comparison between a kinaesthetic image of the strain in the external eye muscles at the end of the first excursion, with the actual strain at the end of the second. This process was not sufficiently analysed to permit of an adequate description. Also *B.* reported a process consisting of eye movement across the standard line with a focal awareness of the kinaesthetic sensations involved rather than of the visual perception. This was followed by an exploitation of the comparison line with a focal awareness of a muscular "hitch" after a certain extent of excursion, reported as equal in extent to the eye movement across the first line. Then the subject, in the case of the difference judgments, was focally aware of a visual perception of either a part of the white card beyond the line or of a portion of the line itself. Vocalization followed automatically. This procedure was essentially the same as that described for Observers *Fs., O.* and *C.* This we believe is evidence of a motor set or preparation in this observer such as was reported by the other subjects.

A second stage, due to the progressive practice which the observers acquired during the experimentation, is to be noted. This occurred at varying periods for the different observers and at first was not very well marked as the observers reverted to the use of earlier methods of procedure. This second stage is marked primarily by the singling out and almost exclusive use of one of the several procedures which were employed at the beginning of experimentation.

In the case of Observer *W.*, this second stage was particularly well marked. In the beginning of experimentation, *W.* employed at least five different kinds of procedures which we have described above,—namely, 1. comparison by means of a visual image of the standard line; 2. fixation between the lines and the perception of the relative clearness of the extreme ends; 3. comparison of kinaesthesis strains of eye movement; 4. comparison of kinaesthesis of strains of accommodation; and, 5. comparison of durations of eye movement. As time went on he employed the procedure of the comparing of strains of accommodation more and more frequently, until this was employed almost exclusively. Also, this observer reported that he was more and more sure that he carried over the accommodation strains from the standard to the comparison lines as an actual innervated muscular set and that the focal experience at the moment of the formation of the judgment was an awareness of an increase or decrease of the intensity of these strains. As time went on, other processes were reported but these only occur in the case of a difficult or doubtful judgment.

At a later stage of development in this series, Observer *Fs.* reported a type of procedure which she at first failed to analyse. This type of procedure was employed exclusively throughout the later experiments. At first she described the process as consisting, first in a focal visual perception of the standard line followed by a focal visual perception of the comparison line, and at once the difference "stood out." This process was described as being very automatic and was followed by very rapid vocal-motor imagery of the judgment. It later turned out that this observer was aware non-focally of muscular sensations of accommodation so that this process is essentially the same as that described for Observer *W.* at this later stage of practice. There is this difference between the content of Observers *W.* and *Fs.* For the former, the kinaesthetic sensations of accommodation were always more vivid than was the visual perception of the line; while for the latter subject, the opposite clearness relations were true.

Observer *O*. never showed any change in his procedure due to progressive practice. This was probably due to two factors. In the first place, this observer never hit upon the method of comparing the two lines by means of the sensations of accommodation, but continued to use the method of exploitation by eye movements as his sole procedure. Secondly, this observer always employed the line which was actually the comparison stimulus as his first line. Hence his apparent standard was continually changing and therefore he had no means of building up a set of kinaesthetic sensations due to practice which corresponded to the standard line.

Practice also had little effect upon the processes of Observer *S*. We find, in the later experiences a great number of absolute judgments and a very great increase in the number of judgments made by carrying over a motor set of accommodation from the comparison line of the pair before. This procedure which has been described above really is characteristic of a still later stage of development that was subsequently reached by some of our observers. Observer *C*. also, as a result of practice had a tendency to judge the lines more and more exclusively on the basis of the sensations of accommodation and his other two procedures, both of which employed exploitation of the lines by means of eye movement, were practically eliminated.

Several of our subjects employed a procedure which we believe marks a still later stage of development in the formation of judgments with stimuli such as we employed in this series. This further development was reached only by those subjects who employed the procedure of comparing the lines by means of changes in the sensations of accommodation. Observer *S*. hit upon this early in his series. The procedure reported above was for the subject to fixate the standard line without eye-movement and then to be focally aware of the strains of accommodation just as the visual perception of the line was clearing up. The subjects then reported the carrying over as an actual motor set these strains of accommodation, and, as the second line was clearing up, they were aware of an increase or decrease of the intensity of these strains in the case of the difference judgments. Now as the result of more practice the subjects never perceived the standard line at all. They reported that they carried over an actually innervated motor set of the strains of accommodation from the comparison line of the pair before; they then at once fixate the comparison line of the next pair and are immediately aware of an increase or decrease in the intensity of these strains. Observers *W.* and C. both reported that their final judgments of difference were made almost exclusively in terms of this procedure; while Observer *S.* employed it infrequently early in his practice and much more frequently in his later experiences. Observer *Fs.* although she employed accommodation changes in her comparings never reached this stage of practice. Neither Observers *O.* or *B.* employed accommodation changes and neither reported anything comparable to their processes to the modification of behavior and content reported by the other observers.

In summary then, we note three stages of mechanization in the process of comparing lengths of lines due to the progressive practice which the subjects received during the experimentation. Each stage of practice showed more or less typical differences in the mental processes which led to the formation of a difference judgment. The first stage was marked for most subjects by the use of a number of procedures. Thus Observer *W.* employed five different types of processes in the formation of his judgments, and *S.* reported as many as seven different types of processes. These are, in general, of three sorts: 1. comparisons made in terms of absolute judgments; 2. comparisons of an imaginal representation of the standard line with a perception of the comparison line; 3. comparisons made on the basis of an actual kinaesthetic set of the first line, the comparison stimulus being perceived in the presence of this set and the judgment of difference being a mere awareness of a change in this set. The processes which consisted in a comparison of an imaginal representation of the standard line with the perception of the comparison line were of two sorts: 1. comparison of a visual image of the standard line with the perception of the comparison, in which case the image and sensation were reported as being absolutely simultaneously present in consciousness; 2. comparison of a kinaesthetic image of exploitation of the lines, in which case the image of the standard line and the sensations from the comparison line were described as not being simultaneously present. The procedures which involved the carrying over of an actual motor set were also of two sorts: 1. the set was described as being localized in the internal eye muscles which have to do with accommodation; 2. it was described as being localized in the external eye muscles which have to do with exploitation. Progressive practice resulted, in the case of every one of our subjects, in the singling out of some one of these numerous types of process. In the case of every one of our subjects a kinaesthetic form of process was singled out and used almost exclusively. Furthermore the kinaesthetic process which was singled out was one involving the carrying over to the comparison stimulus of an actual innervated muscular set, rather than an imaginal representation of the standard line. In the case of two subjects, *O.* and *B.*, the eye movement type of process was singled out, and the movement would stop at a certain point in the exploitation of the comparison line. In the case of the other four observers,—namely *W.*, *Fs.*, *S.*, and *C.*,—the criterion of judgments in terms of a change in the set of the muscles of accommodation was singled out. Finally two of these subjects, *W.* and *C.*, reached a third stage of mechanization. In this stage they still employed the actual muscular set of accommodation when perceiving the comparison line but now this set was carried over from the pair of lines just preceding any given exposure, directly to the comparison line of the next pair; while in the former stage, the set was carried over from the standard to the comparison line of each pair. In this stage of mechanization, the standard line was never actually perceived at all. Observer *S.* had a slightly different development than *W.* and *C.* Observer *S.* reached the third stage of mechanization but he reached it very much sooner and without a well marked intermediary stage as did the other two subjects. His later development consisted rather in a more and more exclusive use of this type of process. Observer *Fs.*, although she employed the same general type of process as Observers *W.*, *C.* and *S.*, never reached the third stage of mechanization. It is rather interesting to note that Observers *O.* and *B.*, who in their second stage singled out the exploitation type of set rather than that of accommodation, never reached anything that approximated the third stage reached by three of the other subjects. This is rather to be expected, inasmuch as one may believe that it would be more difficult through practice to acquire a general set for exploitation than it would for the accommodation changes.

The Comparing of Auditory Intensities

The comparing of sound intensities which led to the formation of a difference judgment were described from the aspect of the attributive pattern of our different observers in the following manner. Observer *W.*, in the early stages of practice, reported the presence of many sorts of criteria in his formation of the judgment. The process at first was very complex. He would first be aware of an auditory perception of the standard stimulus. This auditory perception would seldom remain focal for any length of time, because very soon a kinaesthetic reaction became focal. This reaction, which was described as a contraction of muscles, was reported at first as localized in the eyes, face, neck, throat, shoulders, abdomen, and chest and was usually accompanied by a vocal-motor image of singing the note. Also, in the earlier experiences, there would be a fairly focal visual schematic image of the experimental situation on the other side of the screen, *i.e.* of the dropping of the hammers and the like. Then the subject usually reported that this kinaesthetic reaction was held over as an actual innervated muscular set up to the perception of the second sound. This set remained fairly focal throughout this interval between the two stimuli. With the giving of the second sound, the auditory perception was seldom focal, and this perception was as before accompanied by a visual image of the general experimental situation. In the case of the difference judgments, this subject reported that he was most clearly aware of a change in the muscular set which had been present in consciousness from the perception of the standard stimulus. In the case of a "louder" judgment, he was aware of an increase of the muscular strains and, in the case of a "softer" judgment, of a partial relaxation of these strains. With early practice, a few experiences were reported which made use largely of auditory criteria. In one type of process, this observer was focally aware of an auditory image of the same intensity as the standard stimulus. This persisted focally just up to the perception of the comparison sound. But the image of the standard stimulus and the perception of the comparison stimulus were never exactly simultaneously present to consciousness. Another type of process which was largely auditory in character was infrequently reported. This consisted essentially in an immediate perceptual absolute judgment of the voluminousness of the comparison stimulus without any special imaginal representation of the standard stimulus present at all. With practice very little change was noted in the procedures. There was a tendency for the visual schematic image of the experimental situation to become less and less clear and vivid and less frequent in occurrence. Also the auditory types of judgments were less frequently reported, until finally the focal content in the comparing of these stimuli was the motor set following the perception of the standard stimulus, and the change in this set following the perception of the comparison stimulus, in the case of the difference judgments. Finally, with increased practice, this kinaesthetic reaction and set became much less widespread than it had been in the earlier experiences.

The processes reported by Observer *Fs.* were also very complex. In the first place she reported a non-focal visual image of the entire experience and then a focal schematic visual image of the judgment after it had been formed. Her processes started with the auditory perception of the first stimulus. Then very soon there came into consciousness an auditory image of this stimulus. There was also a vocal motor image of singing the sound and a muscular contraction about the eyes and face, described as a "cringe." Both the vocal motor and the general muscular experience were frequently reported as being held over to the perception of the second stimulus as an actually innervated muscular set. Any one of these three experiences; the visual image, the vocal-motor of humming or the general muscular reaction might be the focal in any particular experience. If the auditory image was held over focally it was usually accompanied by the vocal-motor set as well. Then the judgment was formed at once upon the perception of the second sound stimulus, although the subject always reported that the image of the first sound and the perception of the second were never exactly simultaneously present to consciousness. In the cases where the general muscular reaction was most vivid, the observer was focally aware, for an instant of the auditory perception of the comparison stimulus; and then she would be focally aware of an increase or decrease of the intensity of this set, in the case of a difference judgment,—the increase or decrease leading to the judgments of "louder" and "softer" respectively. Another type of process was employed by this observer but rather infrequently. This consisted in an absolute judgment regarding either the standard or comparison sound. Thus either of the two stimuli were described as having a "jangling" quality while the other would not, and in such cases the sound so analysed would be judged as louder. This process seemed to be partly a tonal analysis and partly due to kinaesthesis in the ear. Practice again seemed to have little effect on the process of comparing for this subject. There was a tendency for the visualization of the experimental situation to drop out or to become less frequently focal. Also there was a tendency for the kinaesthetic processes to become more frequently focal and for the auditory processes to become less frequently focal as experimentation proceeded.

Observer *O.* also presents a very complex process and one which showed remarkably little change with practice. He was first aware of a focal perception of the standard stimulus. Then there was a non-vivid auditory image of this sound which persisted up to the perception of the second stimulus, but which was reported as never being absolutely simultaneously present with it. Slightly more clear, immediately following the perception of the standard stimulus, was a kinaesthetic reaction which involved muscular contractions in the head, eyes, neck, shoulders and body; and this reaction was reported as persisting in an actual innervated set up to the perception of the comparison stimulus. But the focal experience in this period was a vocal-motor reaction of singing the first sound and this also persisted in an actually innervated set up to the perception of the comparison stimulus. Then for an instant, the auditory perception of the comparison stimulus was focally present in consciousness. But very rapidly this subject was aware, in the case of the difference judgments, either of an increase or decrease in the intensity of the vocal-motor set and slightly less clearly of a change in the intensity of the general bodily muscular set which had been carried over from the perception of the standard stimulus. The awareness of this change and of the direction of the change in the muscular sets was essentially the process of the formation of the difference judgments.

Observer *S*. reported a type of process which in most respects was very similar to that employed by Observers *W*. and *O*. All of his experiences were very similar. The standard stimulus was perceived focally for a short time. But then rapidly its place in focal consciousness would be taken by an awareness of a muscular contraction localized in the eyes, neck and shoulders. Observer *S*. reported that these muscular contractions were held in an actually innervated set up to the auditory perception of the second stimulus. This auditory perception was focal for a short time and then Observer *S*. was focally aware either of an increase or decrease in the intensity of this muscular set. This awareness of the change in the set and of the direction of the change, which was apparently an immediate perceptual experience, seemed to be the essence of the formation of the difference judgment. At times, after judgment, this subject would have a visual imaginal schema of the experimental situation. At times before the perception of the first stimulus he would have anticipatory visual, auditory and kinaesthetic representation of the experimental situation. Neither of these processes seemed to be essential, however, to the formation of the difference judgment. We are unable to find that practice had any effect whatsoever upon the processes of this observer in this series of experiments.

A very different picture is presented by the processes of Observer *C*. For this subject, practice made a very considerable change and, indeed, we find three distinctly different types of process corresponding to three distinct stages of practice. At first, this observer always reported anticipatory auditory and visual images of the experimental situation behind the screen, in the fore-period. Then the auditory perception of the standard stimulus would be focal and this would be followed by a clear and focal auditory imaginal representation of the standard stimulus. This auditory image might have either of two temporal courses,—either *C*. reported that it remained continually without variation in clearness or intensity up to the auditory perception of the second stimulus; or he reported that it was intermittent in character, *i.e.*, going entirely out of consciousness and coming in again several times between the perception of the standard and comparison stimuli. In either case, however, the comparison sound was perceived in the presence of this auditory image, although the two were described as never being absolutely simultaneously present in consciousness, and the formation of the judgment seemed to be an immediate experience.

Very soon, however, Observer *C*. reported that his processes had changed very radically. He dropped the auditory criteria of comparing and the process, as now described, was carried on in kinaesthetic terms. The process was very similar to that already described for Observers *W*., *O*., and *S*. Immediately upon the focal perception of the standard stimulus, this subject was aware of a kinaesthetic reaction in the ear and face, which remained as an actual innervated set up to the perception of the second sound. The auditory perception of the comparison stimulus then became focal for a short time and eventually its place was taken by a very clear and focal muscular awareness of an increase or decrease of the intensity of this set. Finally, as the result of still further practice, the awareness of this muscular set between the standard and comparison stimuli, became less and less clear and focal and finally dropped to the physiological level. The process as now described was very simple indeed. From the conscious side, it consisted merely of a focal auditory perception of the standard stimulus, followed by an apparently empty period; then a focal auditory perception of the comparison stimulus of very short duration. Then there was a focal awareness of a contraction or partial relaxation of the facial muscles and a vocalization of the judgment, in the case of the difference judgments. Inasmuch as the subject reported a *relaxation* of facial muscles in the case of the lighter judgments, we must *assume* that a set had been carried over from the perception of the standard stimulus although it had sunk to the physiological level and was no longer conscious.

The description of the processes reported by Observers *B.* and *T.*, who were relatively untrained, need not be given a very complete summary. Observer *B.* gives confirmatory evidence of the same sort of process described by the other subjects, for the comparing of this sort of material. At times she reported the presence of a visual imaginal representation of the experimental situation. Infrequently she reported the presence of a non-focal auditory image corresponding to the sound of the standard stimulus. This, however, was described as being of very short duration and of never persisting until the perception of the comparison stimulus. Most of the time no such auditory image was reported, and indeed, *B.* frequently makes the definite negative statement that no auditory image was present. In every experience, *B.* reported the sort of kinaesthetic process described above for the other subjects. The process, in the case of the formation of the difference judgments, was at first reported as a reflex kinaesthetic reaction localized in the head, body, mouth and tongue, following the auditory perceptions of both the standard and comparison stimuli. Later this was described in terms of a kinaesthetic reaction following the auditory perception of the first stimulus, which was then held in the usual actually innervated set. Then, after the auditory perception of the comparison stimulus, this observer was aware of an increase or decrease in the intensity of this muscular set.

Observer *T.* never reported the presence of an auditory image throughout this entire part of the investigation. He showed two rather distinct stages of practice. In the early stage, his process consisted in an auditory perception of the standard stimulus, followed rapidly by an inhalation, which latter was present to consciousness largely in terms of pressure sensations in the chest. This inhalation was actually held until the auditory perception of the comparison stimulus and then, in the case of the difference judgments, this observer would be aware either of a further inhalation or of a partial exhalation. In a later stage of practice this breathing criterion was replaced by a muscular reaction localized in the head, neck and body and held as an actual innervated set between the perception of the standard and comparison sound stimuli. In the judgment of difference, then, this subject reported either a relaxation or an increase in the muscular strains of this set, immediately following the perception of the comparison stimulus.

In summary then, of the processes which led to the formation of a difference judgment in the comparing of the intensity of auditory stimuli, we find relatively a great deal of similarity between our different subjects. For most of our subjects, the processes were very little changed as a result of the progressive practice which the observer obtained during the experimentation. This is true for Observers *W.*, *Fs. O.*, *S.* and *B.* Observer *T.* showed certain changes but these really consisted in the substitution of one sort of kinaesthetic reaction for another. Observer *C.* on the other hand, showed marked changes due to practice. Three distinct stages are to be found in an examination of his processes, each marked by characteristic structural and attributive differences. Most of our observers report surprisingly infrequently the presence of an auditory image of the standard stimulus, and the presence of such an image seems to have a tendency to drop out or become less clear and focal as practice goes on. Some subjects reported a visualization of the experimental situation but this seems to be unessential to the formation of the difference judgment and again drops out or becomes less vivid due to practice. But all of the observers reported kinaesthetic criteria. The process consisted largely in a kinaesthetic reaction immediately following the auditory perception of the first sound. This remained as an actually innervated kinaesthetic set from the perception of the standard stimulus up to the perception of the comparison stimulus. Then, for a short time, there was a focal awareness of the auditory perception of the comparison stimulus. Then, in the case of the difference judgments, the subjects became focally aware of a change in the kinaesthetic set and also of the direction of that change. If there was an increase in the intensity of this muscular set, the judgment of "louder" was formulated; if there was a decrease in the intensity of this set, or in other words if there was a partial relaxation, the judgment "softer" was given. There were certain rather great variations, however, in the extent of the localization of this motor set. In the case of Observer *W*. it was very widespread, including the eyes, neck, throat, shoulders, chest, abdomen, and also the vocal-motor innervation of singing the note. In the case of the Observer *Fs.*, it was restricted to the eyes and face. The other subjects showed varying degrees of the extent of distribution of this motor set between these two limits.

The Comparing of Visual Brightnesses

In this series the two stimuli were presented simultaneously and in the first space order, *i.e.*, with the standard stimulus always to the left. In the formation of the difference judgments, our several observers showed characteristically different types of procedure in the series of the comparing of visual brightnesses. Observer *Fs.* described her processes from one experience to another in almost identical terms and practice apparently had no effect whatsoever. In the fore-period, this observer fixated a point below the screen. Then, when she was aware in peripheral vision, that the stimuli had come to rest, she rapidly changed her fixation to the standard stimulus. The changes of fixation for this observer were always present to consciousness in terms of a changed visual perceptual field, rather than as kinaesthesis of eye movements. Then there would be a rapid but focal perception of the standard stimulus, followed by a change of fixation to the comparison stimulus and a rapid but focal perception of this gray. Observer *Fs.* reported that her perception of the comparison stimulus was always more clear and vivid but not more durative than her perception of the standard gray. Then there was a return of fixation below to the edge of the exposure aperture, followed rapidly and exceedingly mechanically by a vocalization of the judgment.

Observer *O.* showed very marked changes in his processes due to the progressive practice which he received during the experimentation. In the early stages of practice, this observer reported that he had first a very clear and focal perception of the standard stimulus, with the comparison stimulus seen less clearly and focally in peripheral vision. At once there would be vocal-motor imagery of the judgment. Then there would be a clear perception of the comparison stimulus, focal but of short duration, and this would be followed usually by the vocalization of the judgment. At times Observer *O.* would again clearly perceive the standard stimulus as a verification process. After considerable practice, his processes changed to a great extent. Now he reported that he had first a clear and focal perception of the comparison stimulus, and the formation of an absolute judgment regarding its brightness. This absolute judgment seemed to consist of a visual perceptual process, followed rapidly by a verbal-motor experience of naming the brightness. At times, in this stage of practice, this observer would then have a focal visual perception of the standard stimulus as a verification process; at other times the standard stimulus was never perceived at all.

In the comparing of visual brightnesses, Observer *C.* employed several sorts of procedure. In many experiences he reported a process which was largely immediately perceptual in its nature, *i.e.,* in which both stimuli were perceived simultaneously and the judgment was made on the basis of this double perception. This procedure took two forms,—1. both the standard and comparison stimuli would be seen in peripheral vision with equal clearness and focality; 2. either the standard or comparison stimulus would be perceived focally while the other would be perceived less clearly in peripheral vision. A type of process which consisted in the formation of an absolute judgment upon each of the stimuli was much more frequent however. In this type of process, the standard and comparison stimuli were perceived focally but successively and an absolute judgment was made upon each. This absolute judgment seemed to be an immediate vocal-motor-auditory process of naming the stimulus immediately following the visual perception. Later, as a result of practice, this observer reported that his perception of the standard stimulus was of exceedingly short duration and much less vivid than it had been before,—"as if my eyes were already moving to the second stimulus." This rapid perception of the standard stimulus was not accompanied by an absolute judgment. There would then be a focal perception of the comparison stimulus followed by a vocal-motor-auditory imaginal judgment of the absolute brightness of this second gray. At a still later stage of practice, Observer *C*. reported that he first perceived the comparison stimulus focally and that this was immediately followed by an absolute judgment, which apparently consisted of a mere vocal-motor-auditory imaginal process of naming the brightness as before. Later, the standard stimulus would be perceived focally for a brief period as a verification process.

Observer *B*. employed types of procedures very similar to those reported by the other observers. The most frequent type of process for this subject during early practice, was to fixate between the two stimuli and to perceive part of both with equal focality, simultaneously and in peripheral vision, and then the judgment would be given at once in verbal terms. If the judgment turned out to be difficult, Observer *B*. reported that she would then perceive the standard and comparison stimuli focally and successively several times, and then that she would hold her fixation between the two stimuli and perceive both simultaneously with equal clearness and then vocalize the judgment. In such a procedure the successive fixation of each of the two stimuli would be accompanied throughout by a vocal-motor absolute judgment as to brightness. At a much later stage of practice, another type of process developed for Observer *B*. She now reported that she perceived the comparison stimulus focally, and simultaneously she perceived the standard stimulus less vividly and clearly in peripheral vision. This double perception was followed rapidly by a vocal-motor absolute judgment regarding the brightness of the comparison stimulus. At times this procedure was followed by a focal perception of the standard stimulus as a sort of a verification process.

In summary, then, of the processes which led to the formation of a difference judgment in the comparing of visual brightnesses, we find that for most of our observers the process is a relatively simple one. Several of our observers, namely *Fs.*, *C.* and *B.*, reported a process which consisted in a successive focal perception of the standard and comparison grays. By far the most usual process, in the early stages of practice was one in which the two stimuli were perceived simultaneously, either both in peripheral vision, or one in foveal and the other in peripheral vision. This sort of process was employed by Observers *O.*, *C.* and *B.* Another very frequent form of judgment process which was employed by all four of our subjects included the formation of an absolute judgment on either both stimuli or on the comparison gray alone. This absolute judgment always took a vocal-motor form, which in the case of Observer *C.* was accompanied by verbal auditory imagery as well. Practice seemed to have relatively little effect in this series. The reports of Observer *Fs.* show no appreciable change in her processes as the experiment proceeded. In the cases of Observers *O.*, *C.* and *B.*, there was a tendency for the absolute judgment on the second gray to become more and more frequent, until in the case of observers *O.* and *C.*, they reported that they never perceived the standard gray at all except as a sort of verification process following the formulation of the judgment.

5. *The Attributive Pattern of the Process of Comparing which led to the Formation of the Equality Judgments*

The process of comparing our stimuli which led to the formation of equality or of doubtful judgments were at times so different from those processes which led to the formation of the difference judgments that we have felt the necessity of treating these two classes under different sections.

The Comparing of Lifted Weight Stimuli

In the comparing of lifted weight stimuli, Observer *W.* reported practically the same type of procedures as in the case of the difference judgments in the early stages of practice. In this stage, his process consisted in a successive focal awareness of a kinaesthetic, tactual and visual image of the standard stimulus with the perception of the comparison weight. Observer *W.* reported that the equality judgments were as rapid and as immediate in this stage of practice as were the difference judgments. The doubtful judgments were due to an inability to hold the imaginal representation of the standard stimulus up to the perception of the comparison stimulus. Such judgments consisted merely in an absolute judgment regarding the intensity of the comparison stimulus and were always accompanied or followed by unpleasant affective processes. In the later stages of practice in this series, the difference between the processes which led to the formation of a difference and an equality judgment became apparent. In this later stage of practice, this observer reported the presence of an actual innervated muscular set continuing from the lifting of the standard stimulus until the actual lifting of the second weight. The judgment of difference consisted in an awareness of a difference in either the speed or height of the second lift over this motor preparation and also of the direction of the change. Then the judgment was vocalized at once. In the case of the equality judgments, however, this subject reported that he was aware that there was "no difference" betwen the motor set and the actual lifting of the second weight. But then, the sensations of the lifting of the comparison stimulus remained focal in consciousness up to the top of the lift. Then, when the weight was stationary at the top of the lift, a kinaesthetic image of the lifting of the standard stimulus, refered to the left in a visual spatial manner, became focal in consciousness, and hence another successive comparison of the image of the standard stimulus and the sensations of the comparison stimulus was made.

Observer *Fs.* also showed very little difference in the processes which led to the formulation of a difference and of an equality judgment in the early stages of practice. In the later stages, however, a difference was apparent. This observer also employed, almost exclusively with later practice, the kinaesthetic criteria but reported the presence of an image of the first stimulus rather than an actual innervated set. The equality judgments for this subject were of two sorts. The first type of equality judgment was of a positive and immediate sort. This observer was aware that the sensations of the lifting of the comparison stimulus exactly "duplicated the intensity of the image" of the lifting of the standard stimulus. In such a case the judgment was vocalized at once. A second type of process of a negative sort was also reported in the formulation of the equality judgment. In this case, Observer *Fs.* was able to "note no difference" between the intensity of the kinaesthetic image of the standard stimulus and the sensations of the lifting of the comparison weight. In such a case the judgment was not vocalized until after a verification process, which consisted in a successive focal awareness in consciousness of a kinaesthetic image of the lifting of the standard and comparison stimuli.

Observer *Wd.* also reported different types of process leading to the formation of the difference and the equality judgments. In the case of a difference judgment, the vocalization was made at once. In the case of the equality judgment, however, in the early stages of practice, there was always a subsequent verification process which consisted in a successive focal awareness of the sensations of the lifting of the second weight and a kinaesthetic image of the lifting of the standard stimulus. This kinaesthetic image of the lifting of the standard stimulus came into consciousness always when the comparison weight was stationary at the top of the lift. Such a procedure was at times reported for the difficult difference judgments but it was invariably reported for the equality judgments. This verification process for Observer *Wd.* was always accompanied by unpleasantness and intensive bodily strains. With later practice, the difference in the processes which led to the formulation of the difference and equality judgments seems to have been eliminated. But with the utilization of the actual kinaesthetic set between the two liftings, the equality judgment took on the character of a negative "no difference" type rather than that of a positive equality.

Very little difference could be found in the types of process employed by Observer *P.* in the formulation of the difference and equality judgments. This observer, however, had the negative type of equality judgment and the awareness of "no difference" between the imaginal representation of the standard stimulus and the sensations of the lifting of the comparison stimulus was always accompanied by unpleasantness. Observer *F.* also reported no difference between the processes leading to the difference and equality judgments. This was to be expected, inasmuch as this observer employed with later practice, a visual schema and the formation of absolute judgments exclusively on each of the two stimuli.

In summary, then, we find that for all of our observers except *F.*, namely,—*W.*, *Fs.*, *Wd.* and *P.*,—in the early stages of practice the equality judgment was usually followed by a verification process which consisted in a successive focal awareness of an imaginal representation of the standard stimulus with the sensations of the lifting of the comparison stimulus. The image of the standard weight always came into consciousness and for an instant was focal while the comparison stimulus was stationary at the top of the lift. All these subjects who with practice developed an actually innervated set between the two liftings, were prone to have a negative type of process for the equality judgment, *i.e.* it was rather an awareness of "no difference" between the set and the sensations of the second lifting than of an awareness of positive equality. The experiences of positive equality were sometimes reported however. In such cases, a verification process such as that described above followed this awareness before the vocalization of the judgment. Such a type of process was more or less invariably accompanied by unpleasantness and, for some observers, by general intensive bodily strains. Observer *F.* showed no difference in the processes which led to the difference and equality judgments. But it will be remembered that this observer employed exclusively an absolute judgment on each of the weights of a pair, and also a visual schema of these absolute judgments. Hence in the case of this subject, the negative type of equality judgment would not have been so apparent.

The Comparing of Visual Extents

In the comparing of visual extents the processes which led to the formulation of the difference judgments did not vary appreciably for Observer *W*. from those which led to the equality judgments, in the early stages of practice. With continued practice, however, and with the use of the accommodation type of criterion, the differences between these two types of judgment became apparent. In the case of the difference judgment, the comparison stimulus would be perceived in the presence of an actually innervated muscular set of the muscles of accommodation. With the perception of the comparison line the subject was aware, either of an increase or decrease in the intensity of this set. In the case of the equality judgments, the awareness was of a negative character,—namely Observer *W*. reported that he was aware that no change had taken place in this muscular set of accommodation. In this case, instead of an immediate vocalization of the judgment, a verification process was set up. This consisted in an alternating perception of each of the two stimuli several times with the strain sensations of accommodation focal in consciousness; and even, at times, of a falling back on the other kinds of process used in the earlier stages of practice. These consisted in the use of a visual image of the standard stimulus, the perceptual clearness of the two ends of the lines without eye-movement, the comparing of the kinaesthesis of eye-movement across the lines and the like. Hence the equality judgment for this subject was never so immediate or rapid a process as was that for the difference judgments. The equality judgments, however, after the verification processes were vocalized with a high degree of subjective assurance.

In the comparing of the length of lines, the processes reported by Observer *Fs.*, in the early stages of practice, were of the type of eye-movement across the two lines. In the case of the equality judgment, she would make a certain movement across the standard line and then across the comparison line. Then she would find herself fixating and clearly perceiving the exact end of the comparison line. In the case of the difference judgments, she was aware either of clearly perceiving a part of this line or of some of the white card beyond the line after this movement. The formulation of the equality judgments were quite as rapid and immediate as those of the judgments of difference and the vocalization occurred at once. At a later stage of practice, Observer *Fs.* used the accommodation type of process employed by several of our other subjects. In this case, equality judgments were usually followed by a verification process, for Observer *Fs.*, which consisted of alternating perceptions of the two lines; while, in the case of the difference judgments, no such verification process was present as the judgment was vocalized at once.

Observer *O.* had a group of processes very similar to those reported by *Fs.* in this series. Throughout the entire experiment Observer *O.* employed the muscular experience of eye-movement over the standard line and then across the comparison stimulus for a certain distance. Then he was aware of a sudden stopping of this movement apparently due to a motor preparation set up by the excursion over the first line. Then, in the case of the difference judgments, he would be aware of focally perceiving either a part of the line or some of the white card beyond the line and the vocalization followed at once. In the case of the equality judgments, he would be perceiving the exact end of the comparison line. In such a case unpleasantness and general bodily strains would be present. Then this observer would have a verification process, which consisted in an alternating successive visual and kinaesthetic perception of the two lines until the end of the exposure. Only then would the judgment be vocalized.

There was not so much difference between the processes which led to the formulation of the difference and equality judgments for Observer *S.* Up to the formulation of the initial judgments the processes were essentially the same. When the visual imaginal comparisons were made, the visual image of the standard line would be just as long as the perceived comparison line. In the case of the kinaesthetic procedures, of eye-movement across the lines or of "compassing" the lines with the hand, in which cases an innervated muscular set was reported, the judgment of equality was always of a negative character,—an awareness of no change having taken place in the set. Such judgments were always followed by a verification process which consisted in a mere repetition of the particular process used. This verification process was also at times employed in the case of a difficult difference judgment, but it was more often repeated and was of greater duration in the case of the equality judgments.

The processes of Observer *C.* present the same characteristics as those of *S.* In the case of a motor criterion being used which involved an actual set, the judgment of equality was always of a negative character of an awareness that no change had taken place in the muscular set. In such cases there was a repetition of the process, frequently several times, before the vocalization of the judgment.

Observer *B.* reported two types of process so far as the equality judgment was concerned. If the process was essentially the simultaneous comparison of a visual image of the standard line and the perception of the comparison line, the equality judgment was as immediate as the difference judgments and the vocalizaation occurred at once. In the case of the use of a kinaesthetic criterion and particularly that of eye-movements involving a motor set, the first formulation of an equality judgment was always accompanied by unpleasantness and general bodily strains, and was followed by a verification process before the vocalization of the judgment.

In summary, we find that in the cases of Observers *W.*, *S.* and *B.*, when the process consisted of a simultaneous comparison of a visual imaginal representation of the standard line and the perception of the comparison line, that we are unable to find any essential difference in the processes leading to the formulation of an equality or of the difference judgments. In those cases where the process consisted of eye-movements across the two lines which involved a motor set, as in the cases of Observers *W.*, *Fs.*, *O.*, *S.*, *C.* and *B.*, an equality judgment was always followed by a verification process, which consisted in a continued examination of the two lines before the vocalization of the judgment. Such a verification process was usually accompanied by unpleasantness and an awareness of general bodily strains. In those cases where the process consisted in the carrying over to the comparison line of a distinct motor set in the muscles of accommodation due to the perception of the standard line, the equality judgment takes on a negative character. Hence Observers *W.* and *C.* reported, in the case of the equality judgments, a mere awareness of "no change" in the motor set following the perception of the comparison line. The procedure employed by Observer *S.* of "compassing" the lines with his fingers and holding an actually innervated set to the comparison line should essentially be included in this group although a different set of muscles were employed. Observer *Fs.*, however, described the equality judgment in more positive terms. She reported that the difference of equality of the two lines "stood out" upon her perception of the comparison line. But it will be remembered that the visual perception for this subject was much more focal than the kinaesthetic sensations of accommodation changes. For all of these four subjects,—*W.*, *C.*, *S.* and *Fs.*,— the formation of such an initial equality judgment was followed by a more or less extended verification process and usually by an awareness of unpleasantness and general bodily strains.

The Comparing of Auditory Intensities

The difference between the processes which led to the formulation of difference and equality judgments are perhaps brought out more clearly by this series of experiments than by any other.

Observer *W.* showed the difference very clearly. It will be remembered that, very soon with practice, the process for this observer consisted in a brief auditory perception of the standard stimulus. This was followed by a rather widespread motor reaction, involving muscles in the face and body, and this reaction was held in an actually innervated muscular set up to the perception of the comparison stimulus. Immediately following a brief auditory perception of the second sound, in the case of the difference judgments, this subject was aware of either an increase or decrease of the intensity of the muscular strains of the set and vocalization of the judgment immediately followed. In the case of the equality judgments, the process was exactly the same up to the perception of the comparison sound. Then, immediately following the perception of the second stimulus, this subject reported a mere awareness of no change in this muscular set. The negative character of the equality judgment is evident throughout all of his protocols. In a few cases, this awareness of no change in the muscular set following the perception of the comparison stimulus was followed immediately by a vocalization of the judgment. In most cases, however, a long and complicated process of verification was present. This consisted in a rehabilitation of the entire experimental procedure,—first an auditory image of the standard stimulus followed by the muscular reaction which was held as a set; then an auditory image of the comparison stimulus followed by a focal awareness that no change had taken place in the muscular set. This was accompanied throughout by a visual imaginal schema of the experimental situation behind the screen. Then vocalization of the equality judgment followed.

The processes leading to the equality judgment as reported by Observer *Fs.* were almost identically the same as those described just above for Observer *W*. The equality judgment for her was always of the negative character of no change in the muscular set and was always followed by a verification process which consisted in a rehabilitation of the entire experience,—auditory images of both sound stimuli, vocal-motor processes of humming and the actual kinaesthetic reaction or "cringe" in the face and eyes, before the vocalization of the judgment.

Observer *S.* spoke of the character of the equality judgment in more positive terms. Instead of reporting that no change had taken place in the muscular set following the perception of the comparison stimulus, he reported an awareness of the strains becoming focal and that they "just persisted." He however reported that an experience which culminated in an equality judgment was always followed by a verification process, which consisted in a revival,—often several times successively,—of non-focal auditory images of the two stimuli and a focal awareness of actual kinaesthesis of reaction held in a set from the image of the standard to that of the comparison stimulus. Such a verification process was invariably accompanied by unpleasantness.

Observer *O.* spoke of the awareness of the muscular set following the perception of the comparison stimulus in both positive and negative terms. He reported either that the reaction after the second stimulus "fitted into the set" or that he was aware of no change in the set. There was no verification process reported by this observer and the equality judgments were vocalized as immediately and with as high a degree of subjective assurance as were the difference judgments.

Observer *C.* also described the process of the equality judgment in more positive terms than some of the subjects. He spoke of a continuation of the motor set following the perception of the comparison sound rather than of a negative awareness of no change in this muscular strain. The difference judgments, however, tended to be vocalized more rapidly than the equality judgments. This was because a verification process intervened between the initial formulation of the equality judgment and the vocalization. This verification was an auditory imaginal and kinaesthetic rehabilitation of the entire former experience and was usually accompanied by strains and unpleasantness.

Observer *B.* reported a negative sort of no change awareness in those cases where kinaesthetic processes were employed. Observer *T.* also reported this same negative sort of awareness in the case of the equality judgments. This observer then had a rehabilitation of the muscular sets accompanying the standard and comparison stimuli without, however, the auditory images of these sounds mediating the awareness of the muscular reaction as was the case of our other subjects.

In summary, then, we find that Observers *W., Fs., B.* and *T.* always described the process leading to the formulation of the equality judgments in negative terms in those cases where a motor set was the essential part of the process of comparing. Our other Observers *C., S.* and *O.* reported the persistence of this motor set in positive terms rather than in the negative terms of "no change" following the auditory perception of the comparison stimulus. Observer *S.* always spoke of this persistence in positive terms; while Observers *C.* and *O.* spoke of it sometimes as a positive and sometime as a negative awareness. All of our subjects except Observers *O.* and *B.*, namely *W.*, *Fs.*, *C.*, *S.* and *T.*,—always reported a verification process following an initial judgment of equality. This verification process consisted in the case of Observer *W.*, of a rehabilitation of the entire experience, involving auditory images of both stimuli, the kinaesthetic reaction and set and a visual imaginal schema of the general experimental situation. For Observers *Fs.*, *C.* and *S.*, this rehabilitation involved only auditory and kinaesthetic factors; while, for Observer *T.*, it involved only the rehabilitation of the motor set. Such a process was usually accompanied by unpleasantness and general bodily strains. The vocalization of the judgment did not come immediately after the initial judgment had been formulated, as in the case of the difference judgments, but only after the completion of this verification process. Observers *O.* and *B.* did not report any such verification process but for them the judgment of equality was as immediate as that of difference.

The Comparing of Visual Brightnesses

We are unable to find any differences in the processes described by Observer *Fs.* which led to the formulation of a difference or an equality judgment in this experimental series. The equality judgments were quite as immediate as those of difference.

Such was not the case, however, with all of the other observers who took part in this series. Observers *O.*, *C.* and *B.* reported, after the initial formation of an equality judgment, a successive visual perceptual alternation of the two stimuli a number of times. In the case of Observer *C.* this continued throughout the entire time of the exposure. For Observer *B.* the general procedure was changed. Her first perception was of the two grays simultaneously. In her verification process, she perceived each clearly in successive fashion, and then returned to the procedure of fixating between the two stimuli and of perceiving both simultaneously with an equal degree of focality. This entire process was accompanied throughout by a vocal-motor characterization of each of the stimuli. Such a procedure of verification was also reported by Observer *C.* and was accompanied by hesitation, general bodily strains and unpleasantness.

In summary, we find that there were no differences in the processes described by Observer *Fs.* which led to the formation of equality or difference judgments. This observer employed absolute judgments of the two stimuli almost exclusively in this experimental series. All of the other subjects differed in their procedures in the two cases. In the case of a difference judgment the vocalization came immediately after the completion of the initial experience. In those cases when the initial judgment was one of equality, this was followed for Observers *O.*, *C.* and *B.*, by a continuation of the process. Indeed in the case of Observer *C.*, the process continued until the end of the exposure. Observer *C.* also reported unpleasantness and general bodily strains accompanying this verification process. Observer *B.* actually employed, in verification, a different sort of process than that employed in the initial experience,—changing from a simultaneous to a successive alternating perception of the two gray stimuli.

V. *Discussion and Summary*

In our general discussion, let us first consider the relation of our own results with those of the investigators who have preceded us. These earlier experimental investigators had already shown the fallacies of the positions of Aristotle and of Locke. In the first place they have shown that the process of comparing does not involve a mere simultaneous comparison of a concrete imaginal representation of the standard stimulus in the same modality, with the perception of the second stimulus. This envisagement of the problem, as advanced by Aristotle, is sometimes true, but later investigation has shown that the imaginal representation of the first stimulus may be of other modalities than that of the stimulus. Besides these other surrogate images, the process of comparing may at times not be an actual comparison at all, but rather a mere absolute judgment on one or the other of the two stimuli. Our present results amply confirm the experimental findings which have been brought forward in criticism of the old Aristotelian view.

The concept, advanced by Locke, that comparing is a simple, immediate and unanalysable mental faculty has also been successfully dispelled by all of the recent experimental work. Our own results again are in exact accord with these earlier experimental findings. We now recognize that comparing is a process capable of analysis and description from the various attributive aspects. The fact that this present paper has been written at all, as well as the introspective studies of this process by earlier investigators, is sufficient proof of the incorrectness of this view of a "faculty" psychology, so largely held by psychologists and philosophers from the time of Locke until as recently as the work of Bain. We may also dismiss the concept of Fechner with practically a word. When the general concept of the "innervation sense" was successfully criticized and abandoned by psychologists, Fechner's concept of the process of comparing lifted weights in terms of judgments regarding the intensity of the "sensation of innervation" had obviously to fall with it.

Next, then, chronologically, comes the experimental work reported by Müller and Schumann, which was so instrumental in finally combatting the Fechnerian concept of the "innervation sense." These authors believed that each weight was lifted with the same motor impulse and hence the speed and height of the lifting of the comparison stimulus became of primary importance for these investigators. With this view we have the beginning of the emphasis of the sensory group of kinaesthetic sensations in the formation of such comparison judgments. Martin and Müller, as the result of a later experiment, have extended the concept by further describing the attributive aspects of this process. Müller and Schumann merely stated that both weights are lifted with the same motor impulse. Martin and Müller now explained the mechanism of this process. They reported that the second stimulus is lifted in the presence of a kinaesthetic set or *Einstellung* occasioned by the lifting of the first weight. As we understand Martin and Müller they conceived that this set was not conscious but that it was on the physiological level, and that its presence could only be demonstrated by its effect during the lifting of the second weight. We owe another great debt to the work of Martin and Müller, namely in the pointing out of individual differences in the process of comparing lifted weight stimuli; both between different individuals and for the same individual from time to time. It is due to them that we have the emphasis of the absolute impression of each of the stimuli and the influence of this impression upon the formation of the comparison judgment. For these authors, such an absolute impression is an immediate experience and seems to be present to consciousness in tactual and kinaesthetic sensory terms. Also these authors describe very fully the case of Observer Henri, whose processes were markedly different from those of the other observers employed in the investigation. Henri used, almost exclusively, the absolute impression of each of the stimuli, but this process was mediated by the presence of a visual imaginal schema which the authors carefully described. Fullerton and Cattell published experimental findings which they believed refuted the earlier investigation of Müller and Schumann. They emphasized the cutaneous factors as well as the kinaesthetic, inasmuch as they believed that the subject holds each weight with just enough pressure to keep it from slipping out of his fingers. Kinnaman also analysed this process of comparing lifted weight stimuli. His major contribution is to point out that this process consists of a large number of factors and that at different times any one of these may become focal. Also, if kinaesthetic processes are employed, Kinnaman believed that the judgment was made on the basis of sensations at the very beginning of the lifting of the second stimulus and that the overcoming of the inertia to start the weight seemed to be the important factor. Finally Hayden emphasized the factor of the verbal characterization of the stimuli. This verbalization of the absolute impression is of great importance in this process, Hayden believed, although he accepted the Martin and Müller concept for a motor set. He insisted, however, that the impulse to this adjustment is largely a verbal image which gives the position of the standard weight in a scale of values.

Our results are curiously in accord with practically all of these experimental studies, paradoxical as this may seem. We would still further emphasize, however, the complex character of the process of comparing lifted weight stimuli, as advanced by Kinnaman. This is particularly true in the earlier stages of practice. We believe, on the basis of our experimental results, that the findings of both Martin and Müller, on the one hand, and of Fullerton and Cattell, on the other, are entirely correct. The apparent difference between these two sets of findings is that they are representative of two different stages of practice. We find, in the earlier stages of practice for all of our subjects, that the Martin and Müller factor of the motor set is not present. The judgments are made on the basis of a kinaesthetic and tactual imaginal representation of the first stimulus compared with the sensations involved in the lifting of the second weight. Hence the picture of this stage of practice is very similar to the process as described by Fullerton and Cattell. We would not, however, emphasize the focality and importance of the tactual sensations as these authors have done. Nevertheless the tactual sensations were of great focality and importance from our Observers *W.*, *P.* and *F.* Indeed Observer *F.* employed the exact form of process described by Fullerton and Cattell, inasmuch as he reported the focality of the tactual sensations on the ends of the fingers, and also reported that each stimulus was grasped with just enough force to keep it from dropping. For our other observers, however, the tactual factors were either not reported or they were said to be present with a relatively low degree of clearness. For these observers the kinaesthetic factors seemed to be of much greater importance and they were certainly present to consciousness with a much greater degree of vividness. However, the important point for this present discussion is a substantiation of the claim of Fullerton and Cattell that at times the Martin and Müller factor of the comparison stimulus being lifted in the presence of a kinaesthetic set, and that the formation of the judgment is dependent upon the speed and height of the lifting of the comparison weight, is not true. We find, on the basis of our experimental data, that this absence of the motor set, however, is true only for the early stages of practice.[1]

We also find that our results are in gratifying close agreement with those of Martin and Müller, with but a single and in a sense non-essential exception which we will consider later. But this agreement is true only for our results at late stages of practice. Indeed the description which Martin and Müller give of the process of comparing is even closer for this process, as we found it in later stages of practice, than is the description of Fullerton and Cattell for the process in our early practice. We found in late practice, and in agreement with Martin and Müller, the

[1] Since the writing of this paper we have seen some evidence that is, at least, confirmatory to part of our present contention,—namely, that the subjects employed by Fullerton and Cattell were relatively untrained. M. Cowdrick, The Weber-Fechner Law and Sanford's Weight Experiment. *Amer. Jour. of Psychol.*, XXVIII, 1917, 585-588, finds that for practiced subjects the results in lifted weight experiments closely approximate the Weber-Fechner Law, while for unpracticed subjects the results more nearly approximate the so-called Square Root Law of Fullerton and Cattell.

presence of a motor set or preparation occasioned by the lifting of the first weight. Then the comparison stimulus was lifted in the presence of this motor set and the process of comparing consisted essentially in an awareness of the speed and height of the lifting. This was true for all of our observers but one,—namely Observer *F*. This latter, interestingly enough, developed with practice a type of process which was almost identical to that employed by the Observer Henri in the earlier investigation. This consisted in the use of the absolute impression of each stimulus with a mediating visual imaginal schema. It turns out that the visual schema for these two subjects were identical as nearly as we can tell from the descriptions. We would also emphasize the presence, from time to time, of the absolute impression for other observers. Furthermore, and in accord with the statements of Martin and Müller, we believe that this absolute impression is an immediate tactual-kinaesthetic experience. As least, we were unable to obtain any analysis of this experience from our observers.

We would make this very radical distinction, however, from the analysis of the process of comparing as advanced by Martin and Müller. So far as we can tell from their statements, they conceived the motor set in the presence of which the comparison stimulus was lifted, largely in terms of an experience on the physiological level, and either without accompanying consciousness at all or with a very low degree of clearness. The experiences of our observers lead to very different conclusions. They were all very highly conscious of this motor set and practically all of them described it emphatically as an actual innervation of the muscles,—"as an actual muscular tetanus" and not as an image or a process on the physiological level. It is rather difficult to make a comparison of the two studies here. Martin and Müller were much more interested in the *effects* of this set than in the academic question involved and so do not express themselves with as much clearness on this point as one might wish. Also they publish very few of their introspective reports so that a study of these is unfruitful in clearing up the point. We hope to show later in this discussion that the concept that this kinaesthetic set is an actual innervation of the muscles accompanied by a consciousness of the muscular strain, explains a great deal more either than the concept of this being an imaginal experience or of it being an actual innervation but on the physiological level and without conscious representation.

Our results agree only in part with the findings of Hayden. The results of the two studies agree in that we also find verbal characterization of the stimuli frequently forming a part of the experience of absolute impression, although we would by no means emphasize it to the extent that we find in Hayden's conclusions. But we find no evidence at all that this verbal characterization of absolute impression is the important factor, or even an essential factor, in forming the motor adjustment following the perception of the standard weight. Our results show, rather, that the lifting of the standard stimulus itself is the impulse to the formation of the motor set or adjustment.

Our results are also in more or less accord with the findings of Whipple in his study of discrimination of tones and clangs. We find, in the first place, that the imaginal representation of the standard tone need by no means be of the same modality as the standard stimulus. Whipple reports that in some experiences an auditory image of the standard stimulus may be present in consciousness and may not be focal; while, in other cases, there is no trace at all of an auditory image. Our results confirm this finding, except that we would insist that, after considerable practice, all of our subjects reported the *absence* of the auditory image as the rule rather than as the exception. We would emphasize, therefore, especially after practice, the presence of factors other than the auditory, and especially the kinaesthetic, in the comparing of auditory intensities. Indeed Whipple has given a picture of the experiences in which no trace of an auditory image is apparent, which closely resembles that given by our subjects. Whipple says that such experiences are "largely analysable into complexes of strain sensations with less prominent visual and organic elements, set free neurologically by the comparison stimulus." We would emphasize still further the kinaesthetic factors rather than the visual and organic elements. Indeed Whipple makes this same emphasis as he continues: "The two chief factors, feelings of tightening and relaxation for higher and lower respectively . . ." This intimates that the process consisted essentially in the holding of a motor set which then increased or decreased in intensity after the perception of the comparison stimulus. This was identically the process reported by our observers. Also Whipple reports that in the formation of the "equality judgment there is an alternation of auditory images and a real comparison." This appears to be identical to the verification process so frequently reported by our observers. We would differ from Whipple in one respect, however, and that is in our emphasis of the kinaesthetic factors in such a verification process. Our subjects reported usually the presence of such auditory images but they seemed to be a mere rehabilitation of the experimental situation, and then the kinaesthetic set and the muscular strain sensations became very much more focal. However, our results are in surprisingly close agreement with those of Whipple. This is true in regard to the insistence that, in auditory experiments, the presence of an auditory image of the standard stimulus is not essential. Secondly we both emphasize the kinaesthetic factors in such a process and, so far as we can tell, it would appear that the description of the kinaesthetic set was at least intimated by Whipple's observers, as it was reported by those in our investigation. Furthermore, the two studies agree essentially regarding the character of the process underlying the formation of an equality judgment.

With regard to our experiments with visual brightnesses as stimuli, we have little material with which we may compare our results. This is largely because both Angell and Bentley, in working with visual brightnesses, exposed their stimuli in successive fashion and with rather long intervals between the standard and comparison stimuli, while we exposed our stimuli simultaneously. Our own results amply verify some of the findings of their observers, however. Angell observed, for his short exposures, that his subjects attempted to keep uniform sensory conditions, such as bodily strains, breathing and the like for both of the stimuli. We observed a similar tendency for all of our subjects. Also Angell and Bentley both emphasize the presence and importance of verbal processes in characterization of the stimuli. This was a very frequent type of process for our own observers. We are unable to make any comparison of Bentley's type of visual imaginal process with our own results. This type of process was not reported by our observers. The reason for this is very obviously to be found in the differences in the manner of the presentation of the stimuli in the two experiments. In Bentley's experiment, where a successive presentation of standard and comparison stimulus was employed, the presence of a visual image of the first stimulus would be expected. This procedure was not used in our experiments, in which the two stimuli were exposed simultaneously. Instead we found a visual perceptual process, inasmuch as it was possible for our observers to perceive both stimuli, or at least parts of them, simultaneously.

We are unable to find in the literature an introspective analysis of the process of comparing any materials similar to the visual extents such as we employed. The results of this series of experiments, however, are extremely closely in accord with the results in the lifted weight series. In the early stages of practice we would emphasize the extreme complexity of the process, and here our results would agree with those of Kinnaman's experiments with lifted weights. As time went on, and with progressive practice, the kinaesthetic factors were singled out, and finally we find the development of a definite kinaesthetic set or *Einstellung* entirely comparable to the motor preparation described by Martin and Müller for lifted weight experiments. The only difference in the motor set as described by Martin and Müller, for lifted weights and by our own subjects for the comparing of visual extents, is in the localization of the particular muscles involved and also in the case of the earlier investigation it is described as being on the physiological level; while in the present investigation this set was described as being very highly conscious.

In summary, then, we find that our results are curiously in accord with those of the experimental studies which have preceded this one. It is gratifying and interesting to note that they are in accord with the results of both Fullerton and Cattell, on the one hand, and with those of Martin and Müller, on the other hand, paradoxical as this would seem. But we find that the difference in these two sets of results is due to the fact of their being pictures of the process of comparing at different stages of mechanization, due to the progressive practice which the subject obtains during the experimentation. Thus the type of process for the comparing of lifted weights, as described by Fullerton and Cattell, is essentially the process as described by our subjects in the early stages of practice. We would, however, in agreement with Kinnaman, insist that the process is very much more complex than the description given by Fullerton and Cattell. One of our observers, however, *P.*, gave a description of the process in these early stages which seems to be exactly similar to that described in the earlier investigation. On the other hand, the reports of our observers for the later stages of practice in the lifted weight experiments, are almost identical to those described by Martin and Müller. This is true for the description and emphasis of the motor set, in the presence of which the comparison weight is lifted; for the presence and character of the absolute judgments; and for the apparently anomalous case among the observers. Thus our Observer *F.* and Observer Henri, in the former investigation, both developed a form of absolute judgment with a mediating visual imaginal schema which was very similar if not identical. We differ from Martin and Müller only in that we would lay more emphasis on the highly conscious character of the motor set. We conceive the impulse to the formation of this motor set, however, in the same terms that they do,—namely by the lifting of the standard weight directly and not, as it is explained by Hayden, by the verbal characterization of the intensity of the standard stimulus. Our results, in the experiment of the comparing of visual extents, are also completely in accord with these experiments with lifted weight stimuli. Unfortunately, there are no introspective analyses in the literature of the process of comparing lengths of lines with which we may directly compare our results.

We are also unable to make any direct and very fruitful comparison of our results in the experiments with visual brightnesses and those of the former studies which employed such stimuli. The reason for this is that both Angell and Bentley employed a successive exposure, while we employed a simultaneous exposure of the two stimuli. However, we would emphasize, along with both investigators, the frequency of occurrence and the importance of the verbal characterization of the two stimuli in the making of such determinations. Our results are also in agree-with those of Angell in the fact that our subjects kept constant conditions of observation throughout the experience. Our results are also in complete accord with those of Bentley with regard to the fact that the simple comparing of two gray stimuli is capable of a considerable latitude of modes in which the process may be present.

Finally, our results in the comparing of sound intensities are in accord with those of Whipple. The observers in both investigations reported the presence of processes in which the auditory image was very focal, and also processes in which there was no trace of an auditory image. In these latter experiences, the subjects in both investigations reported the presence primarily of sensations of muscular strains. Furthermore we believe that the process in these cases is exactly similar,—consisting essentially of the presence of a kinaesthetic set, present from the perception of the standard stimulus up to the perception of the comparison stimulus. Although Whipple does not describe this motor set, nevertheless his description would most certainly imply that such a set had been present.

In the light of our results, however, these earlier investigations seem to be lacking in two respects. In the first place they have all failed to note differences in the processes of comparing for different stages of practice. This we believe is the sole basis for the Fullerton and Cattell-Martin and Muller controversy. In the second place, these investigations have failed to give an adequate and complete description of this process. We are able to amplify these earlier descriptions, we believe, largely because of the great advances which have recently been made by the method of systematic, experimental introspection.

The description of the process of comparing for all of our four experimental materials is exceedingly simple as considered from the structural point of view. Our observers reported the frequent presence of images and of sensations of different modalities. In the case of lifted weights, sensations and images of a kinaesthetic, visual and tactual sort were reported. In the cases of lengths of lines, tones and visual brightnesses, these processes were described largely as visual and kinaesthetic. There was a tendency in all of these series for the different modalities to be very frequently present in the earlier stages of practice. With variable periods of practice, there was a tendency for the kinaesthetic experience either to be reported alone or to be focal. Furthermore, as a result practice, there was a tendency for the observers to describe this kinaesthetic experience as a sensation, where formerly they had described it as an image. Affective experiences were either infrequently mentioned by some of our subjects or they were not mentioned at all by others. In those cases where affective processes were mentioned, they did not seem to be an essential part of the process of comparing, but rather referred to the degree of subjective assurance of the observer. In this respect our results agree entirely with the experimental portion of Marbe's investigation of the judgment consciousness. The experimental arrangements and the materials of the two studies were so different that a detailed comparison is not possible. Both Marbe's and our own subjects discovered, however, only the elemental processes of sensations, images and affections. Marbe expressed this finding in negative terms when he said that he was unable to find any new structural element which differentiated the judgment from a mere association of ideas. He continued, then, to say that such a difference undoubtedly exists, and he believes that the difference is to be found in the intention of the observer to judge. We believe that a very different interpretation is to be placed upon these findings. It is true that there are no apparent structural experiences which differentiate the higher mental processes from one another. The differentiation is rather to be sought in the synthetic aspects. That is, in making such a differentiation, it does not seem to be so essential *what* is present in consciousness;

but rather the emphasis must be on *how* this content is present. This is the view held recently by several investigators in the field of the higher mental processes.[1]

Let us consider then the particular *pattern* which the structural content took in consciousness in the process of comparing. It will already be obvious that this pattern varies considerably from case to case dependent upon three general conditions. The first of these is the material which is presented for comparing and the form of presentation of the material. The second is the particular subject who does the comparing; his imaginal type and the like. The third is the stage of progressive practice in which we find this individual. But although there are certain differences between individuals in the pattern of this conscious process still, on the whole, there is a certain and marked similarity between the processes as reported by our subjects.

Let us first consider as a group the process of comparing as it is found for stimuli of our first three groups of experiments,—namely, lifted weights, visual extents and sound intensities. The process, in early stages of practice, was essentially a complex one for all of our observers and for all these sorts of stimuli. It consisted of a focal perception of the standard stimulus, and then of an immediately successive and highly focal awareness of an imaginal representation of the standard stimulus with a perception of the comparison stimulus. The imaginal representation of the standard stimulus was usually complex, involving images of several modalities; the particular modalities which were present or focal depending upon the imaginal type of the observer, and apparently partly upon mere chance. We have spoken, first in temporal order, of the perception of the standard stimulus. It will be remembered in the case of the comparing of visual extents, that the stimuli were presented simultaneously. The protocols show that, even in this case, there were very few experiences in which the two stimuli were actually perceived simul-

[1] E. L. Woods, An Experimental Analysis of the Process of Recognizing. *Amer. Jour. of Psych.*, XXVI, 1915, 313-387.

S. C. Fisher, The Process of Generalizing Abstraction; and Its Product, the General Concept. *Psychol. Mon.*, XXI, No. 2, (Whole No. 90), 1916.

taneously,—the process, in the very great majority of the experiences, was of a successive sort. Gradually, as a result of practice, the imaginal representation of the standard stimulus became more and more simple. There seemed to be a singling out of the kinaesthetic factor and a dropping off of the occurrence of the images of the other modalities, no matter whether the stimuli were of a kinaesthetic, visual or of an auditory sort. Then gradually the observers reported, with more and more conviction, the fact that the representation of the first stimulus was a kinaesthetic sensation, *i.e.*, an actual innervation of the musculature.

This marked the second stage of development due to practice. In this second stage, the process of comparing consisted essentially of the following experiences. There was first a perception of the standard stimulus, which was focal for a brief period. This perception, in the cases of lifted weights and of visual extents involved a necessary kinaesthetic reaction,—of lifting the stimulus in the case of lifted weights; and either of eye-movement or of accommodation in the case of visual extents. For the auditory stimuli, where no such muscular adjustment was *necessary* for the clear perception of the stimulus, there was always a motor reaction of "cringing" immediately following this perception. Most of the subjects reported, with all of these stimuli, that the muscular reaction was more focal than the actual perception. Then the muscular strain, which was actually innervated, was held from the perception of the standard stimulus to the perception of the comparison stimulus. This comparison stimulus was then perceived in the presence of this muscular set or preparation. In some cases the perception of the comparison stimulus was focal but for only a brief period; in other cases it never became focal. In either case the highly focal experience was the kinaesthetic set and the subjects reported that they were now aware either; 1. of an increase in the intensity of this set, —of a further muscular contraction,—which led to a judgment of "greater"; 2. of a decrease in the intensity of this set,—of a partial muscular relaxation,—which led to a judgment of "less"; or 3. to a condition described in positive terms as a "persistence" or "continuation" of the set, or negatively as an awareness that "no change" had taken place in the set, which led to a judgment of "equality." One variant, in the case of some observers of the comparing of visual extents, occurred in the eye-movement type of process. Here the comparison stimulus was perceived in the presence of a motor set but now, instead of the subject being aware either of a mere continuation of the set or of a change in the set, he was aware of a sudden stopping of the eye-movement. He was then focally aware of perceiving either a part of the line, the end of the line, or the white card beyond the line. These perceptions led respectively to the formation of "greater," "equal" or "less" judgments. In the case of the difference judgments, the subjects vocalized the judgment at once and the process was completed. In the case of the equality judgments, however, there was usually a re-perception of the two stimuli, in the case of visual extents where the two stimuli were presented simultaneously. In the cases of lifted weights and auditory intensities, there was usually the rehabilitation of both stimuli in successive fashion and usually this rehabilitation was more complex than the mere kinaesthetic reactions, involving the imaginal representation of the stimuli themselves.

At this second stage of practice another feature became prominant. This was the frequency and apparent importance of the formation of absolute judgments regarding the stimuli. These absolute judgments seemed to be immediate perceptual experiences with, in the case of some observers, universal verbal characterization. In the case of one of our observers,—namely Observer *F.*,—this process became essential in his comparing of lifted weight stimuli. This subject never employed the type of process which consisted essentially in an awareness of persistence or change in a muscular set. The process of comparing for him consisted, after practice, in a mere absolute tactual judgment of each of the weights, mediated by a very highly developed visual schema.

In the experimental procedure with the comparing of visual extents, several of our observers reached a third stage due to continued practice. This was based upon the formation of the type of process found for the second stage. This consisted, briefly, in the assuming of the motor set, always of the muscles of accommodation, from the perception of any given pair of lines. Then, when the next pair came into view, the observer was aware of a perception of the comparison stimulus and focally aware of a change or of a persistence of the motor set. In such an experience, the standard line of the second pair was never actually perceived at all. Such a third stage was never reached in the procedures with weights and sound intensities as stimuli. The reason for this is very obvious. In those arrangements where the stimuli were presented simultaneously, as in the case of visual extents, it was possible for the subject to disregard the standard stimulus. In those arrangements, however, where the stimuli were presented successively as in the case of weights and sounds, such a disregarding of the standard stimulus was impossible because the perception of such a stimulus alone filled a certain period of time.

The case of comparing visual brightnesses calls for separate treatment. In this series the stimuli were presented simultaneously and, as it turned out, so close together that parts of them at least could be perceived simultaneously. In this case, two general types of process were reported. Either the two stimuli were perceived simultaneously or they were perceived successively. In the cases where they were perceived simultaneously,—either both in peripheral vision or one in peripheral and the other in foveal vision,—the process consisted apparently in an immediate perceptual experience with verbal characterization of the stimuli. In the cases where the perceptions of the two stimuli were successive, the process consisted largely in the formation of an absolute judgment of each of the stimuli. This seemed to be an immediate perceptual experience with verbal characterization. Practice seemed to have little or no effect upon the process of comparing stimuli of this modality. In the cases of several subjects, there was a differentiation between the processes which led to the formulation of the difference and equality judgments. In the case of the difference judgments, the observer at once vocalized the judgment and then turned away from the problem. In the case of the equality judgments, however, there was a continuation of the perception of the stimuli, in some cases up to the end of the exposure.

The process of comparing visual brightnesses seems to be considerably different from those of the comparing of the stimuli of the other modalities which we employed. The reason for this difference is to be found, we believe, in the fact that, in the case of the grays, the stimuli were so arranged that they could be perceived truly simultaneously. In such a case there was no necessity for carrying over an imaginal or kinaesthetic representation of the first stimulus. The process of comparing in this case is capable of being accomplished on the mere perceptual level. Also we find a great emphasis, in this series, of the absolute judgment and of the verbal characterization of the stimuli in those cases where the stimuli were perceived successively. The reason for this may be that it is difficult to determine what sort of a kinaesthetic reaction other than verbal could be employed, so that the observer might carry a set from one stimulus to the other. This sort of absolute verbal characterization occurred less frequently in all of the other series of experiments. The only real difference is that, in the case of comparing visual brightnesses, the verbal absolute judgment was employed instead of the motor set as a representation of the standard stimulus.

Such then is the general picture of the process of comparing for our different subjects, for our different materials and experimental arrangements and for the different stages of practice. Such a description obviously emphasizes, particularly in the later stages of practice, the frequent presence and apparent significance of kinaesthetic factors, no matter what the modality of the stimuli which were compared. It is a matter of great interest to know why the kinaesthetic modality should have this great advantage over all other modalities of sensation. It is a curious fact that all forms of sensation should be transposed into kinaesthetic terms,—that kinaesthesis should become the "common denominator" of all of the other modalities of sensation. We believe that it is possible to explain this on a purely speculative basis. In the cases of visual and auditory, or any of the modalities other than the kinaesthetic, if one desires to retain a representation of an experience, he can do this only in terms of an image. In the case of kinaesthesis, and this is the only modality in which it is possble, the representation of a former experience may be retained in terms of an actual sensation, by actual innervation and continued strain of the musculature involved, and not in terms of an image. We do not mean to deny the existence of the kinaesthetic image. The existence of such an image is entirely beside the point under discussion. We merely wish to emphasize the fact that in the case of the kinaesthetic modality, and here alone, there is a possibility of retaining a representation of a sensational experience in terms of a true sensation by means of a continuation of the innervation of the muscles involved or, in other words, by an actually innervated kinaesthetic set. In the case of all modalities other than the kinaesthetic, the retaining of a representation of a past experience can be possible only in terms of an image. This, we believe, gives the kinaesthetic modality a vast superiority over all of the other modalities of sensation and is the reason why, in our experiment, we found all of the other modalities translated into kinaesthetic terms.

The very frequent occurrence of the kinaesthetic set in the process of comparing stimuli of the different modalities, is capable of explaining several facts which have been brought out statistically in the experimental literature. We have spoken of the change from a complex form of comparison process to the presence of a kinaesthetic set as being due to the progressive practice which the subject obtains during the experimentation. Let us look at that relationship from another viewpoint. It has been determined,[2] in the case of lifted weights, that one of the most obvious effects of progressive practice is to decrease the size of the interval of uncertainty, the distance between the lower and upper thresholds. This means, as practice continues, that fewer

[2] F. M. Urban, Der Einfluss der Uebung bei Gewichtsversuchen. *Arch. f. d. ges: Psychol.*, XXIX, 1913, 271-311.

S. W. Fernberger, The Effects of Practice in Its Initial Stages in Lifted Weight Experiments and Its bearing upon Anthropometric Measurements. *Amer. Journ. of Psychol.*, XXVII, 1916, 261-272.

and fewer equality and doubtful judgments are given because the size of the interval of uncertainty is directly dependent upon the number of equality judgments. Now along with this decrease in the number of equality and doubtful judgments, on the statistical side, we find a change, on the side of the process itself, from a comparison made by means of an image to one made by means of a sensational representation of the standard stimulus. Inasmuch as we believe that we have shown the superiority of the kinaesthetic sensation over the images of any modality in such a process, we would be surprised if this change from an imaginal to a truly sensational form of comparison were not accompanied by a decrease in the number of equality and doubtful judgments which the subjects reports. Such a decrease would show itself, as it actually does, in a decrease in the size of the interval of uncertainty or in an *apparent* increase of the sensitivity of the subject.

Some time ago we found[8] that mental work had practically no effect, or at least a very variable effect, upon the formation of judgments in lifted weight experiments. Physical work, which consisted in tiring the hand which did the lifting up to the point of painful fatigue, had a very great effect in markedly increasing the size of the interval of uncertainty and in very markedly decreasing the size of the point of subjective equality. The subjects employed in this investigation were highly trained observers and hence we may believe that the process of comparing for them consisted essentially in the presence of a kinaesthetic set occasioned by the lifting of the standard stimulus and of an awareness of persistence or of change in this kinaesthetic set immediately following the perception of the comparison stimulus. The statistical results argue most strongly for this kinaesthetic set being present in actual innervation of the muscles and not as an image. If the set were present as an actual innervation, one would expect that physical fatigue of these same muscles would tend to make the determinations less accurate. A decrease in

[8] S. W. Fernberger, The Influence of Mental and Physical Work on the Formation of Judgments in Lifted Weight Experiments. *Jour. of Exper. Psychol., I,* 1916, 508-532.

accuracy is always present in terms of an increase in the number of equality and doubtful judgments, which show statistically as an increase in the size of the interval of uncertainty. This is exactly what a statistical treatment of the results did show. But the marked lowering of the point of subjective equality as a result of physical work argues still more strongly for the fact that this kinaesthetic set is actual and not imaginal. With physical fatigue of the peripheral muscles concerned in the lifting, one would expect that there would be an inability to hold the set at its proper intensity. In other words, a fatigued muscle tends to relax. Hence this partial relaxation of the set leads to an overestimation of the comparison weight and obviously shows itself, statistically, as a decrease of the size of the point of subjective equality. If this kinaesthetic representation of the first stimulus were an imaginal experience, we would expect mental work to have the above effect because mental work would tend to decrease the ability of the subject to hold an image at its constant intensity. On the other hand, we should expect mental work to have but little effect on the ability to maintain an actual contraction. The statistical results point to exactly the opposite conclusion.

But what is perhaps of still greater importance is the fact that the presence of this motor set explains the distinction which has been made by some experimenters between the equality and difference judgments. From Fechner down there has been a great deal of discussion about the choice of judgments to be made in a psychophysical experiment. Fechner[4] objected to the use of the equality judgments. Other investigators who have objected to the use of the equality and doubtful judgments are Fullerton and Cattell, Jastrow, Higier, Sanford and Brown.[5] It has been

[4] G. T. Fechner, *Elemente der Psychophysik.*, 2d. Edition, Leipzig, 1889, Vol. I, p. 72 ff.

[5] G. S. Fullerton and J. McK. Cattell, *The Perception of Small Differences.* Philadelphia, 1892, Pp. 59 ff.

J. Jastrow, A Critique of Psycho-Physic Methods. *Amer. Journ. of Psychol.*, I, 1887, 271-309.

H. Higier, Experimentelle Prüfung der psychophysischen Methoden in Bereiche des Raumsinnes der Netzhaut. *Phil. Stud.*, VII, 1892, 232-298.

E. C. Sanford, *A Course in Experimental Psychology.* Boston, 1898, Pp. 357 ff.

W. Brown, The Judgment of Difference, with Special Reference to the noted then from the early experiments that there has been a difficulty in handling the equality judgments. There can be no doubt that the true equality judgment does exist but it seems to be particularly dependent upon the subjective standards of the observer. We determined the influence of these subjective standards by an experiment in lifted weights.[6] In this experiment we employed two groups of subjects. To the first group we gave the usual instructions, which we believe led to the formation of an attitude of looking for a difference. To the second group we emphasized the occurrence of the equality judgments in our instructions. The results show that many more equality judgments were given by the second group, and hence the interval of uncertainty for this group was larger than that for the other. An introspective analysis of this particular problem has recently been published by George.[7] He works with sound intensities and visual extents as stimuli and he was particularly interested in studying the mental basis of the doubtful judgment. He finds that a low degree of subjective assurance and expectation are two very potent factors in the formation of these judgments. He also closely identifies the "non-difference" judgment with doubt on the part of the observer. George's published introspections are so definitely toward describing his particular problem of the attitude of the subject, rather than of an analysis of the process of comparing in general, that it is impossible to compare the results of his study with the reports of our observers.

We have shown in our historical sketch above that many investigators have insisted that all equality judgments are negative in character from the introspective side. Hayden believes that judgments of equality are only made when the criteria for the other judgments are lacking, and that they are always accompanied by uncertainty. Angell, working in the field of sound intensities, takes up this problem of the negative character of the

Doctrine of the Threshold, in the Case of Lifted Weights. *Univ. of Calif. Pub. in Psychol.*, I, 1910, Pp. 6 ff.

[6] S. W. Fernberger, The Effect of the Attitude of the Subject upon the Measure of Sensitivity. *Amer. Journ. of Psychol.*, XXV, 1914, 538-543.

[7] S. S. George, Attitude in Relation to the Psychophysical Judgment. *Amer. Jour. of Psychol.*, XXVIII, 1917, 1-37.

equality judgments. His analysis shows that equality judgments are almost always negative in character in the early stages of practice. In the course of time, however, this absence of difference becomes a positive mark and, then, equality judgments are given with a great degree of conviction. Angell conceives the structural basis of this change as due to the development of an abstract state of knowing,—a *Bewusstheit*. Whipple draws a distinction between the difference and equality judgments, inasmuch as the processes which led to the formation of the equality judgment were less immediate and usually had an alternation of images of the two stimuli, which was not present for the processes which led to the formation of the difference judgments.

Our own experiments also show a difference, for most of our series and for most of our subjects, between the character of the difference and equality judgments. Whether this is because our subjects had an "active attitude" rather than the "passive attitude" recommended by George, we are unable to say. At any rate the difference existed. In the first place the quality judgments were seldom so immediate as the difference judgments and they were usually given with a lower degree of subjective assurance. Thus, in the case of the difference judgments, the judgment was vocalized at once and the process was completed. In the case of the equality judgments, there was almost invariably a verification experience, which consisted in an alternation either of a perception of the two stimuli or of an imaginal representation of them. Such a verification process was frequently accompanied by unpleasantness and general bodily strains. Furthermore, after practice and with the development of a kinaesthetic set as the basis for comparing, the difference judgments were always described in positive terms, while the equality judgments were almost always described in negative terms. Thus the process for a "greater" or "less" judgment was described as an awareness of increase or decrease in the kinaesthetic set. The process leading to the formulation of an equality judgment was described as an awareness of "no change" in this kinaesthetic set. In some instances this was described in positive terms as a "persistence" or a "continuation" of the muscular set, but these cases are far in the minority. This seems to be direct evidence that there is a difference between these two experiences.

The question at once arises if we are not dealing here with a mere verbal difficulty. That is, the expression "no change" was simply used as the opposite of "change" without any idea in the mind of the observer that he was describing his processes in negative terms. We do not believe that this is the case but rather that here we have a real difference. It is reasonable to believe that an observer would be more readily aware of a change of kinaesthesis than of the fact that there has been a mere persistence of the process. An observer would be more readily aware that the muscles in his neck are contracting or relaxing, than simply that the muscles of his neck *are contracted*. Such a state of affairs would undoubtedly lead to the formation of an attitude of looking for a difference, inasmuch as a difference is more readily and more clearly perceived. Once this attitude had been formed the subject would view with suspicion all experiences in which he was unable to note a change. Thus these would be accompanied by a low degree of subjective assurance because the observer would believe that he might have missed the perception of a slight change. This would lead to a verification process which would consist in a repetition of the process. As a matter of fact, the introspections of our observers show that this is exactly what does happen in the single experience. Whether the speculative picture of the genetic development of this attitude is true or not we are unable to tell from our protocols. Certainly such a state of affairs would account for the negative character of the equality judgment after the attitude of looking for a difference has been developed, in those experiences in which a kinaesthetic set had been employed. The formation of this attitude of looking for a difference is conditioned, we believe, by the fact that a muscular change is more apt to get into focal consciousness than a mere awareness of persisting muscular strain.

There is other direct evidence of the truth of this contention from the reports of our observers. This is found in the fact that no differentiation could be made between the difference and equality judgments, in those experiences in which a kinaesthetic set was *not* present, and more particularly in those experiences in which the judgment was made entirely on the basis of an absolute impression of each of the stimuli. In such experiences there were no verification processes reported, in the case of the equality judgments. Also the equality judgments were vocalized apparently as immediately and the process completed as rapidly as were those of difference.

The discussion of verbal difficulties leads us to quite a different matter,—namely the use of the term "recognition" for the awareness of difference or equality in processes of this sort. If the term "recognition" should ever be properly applied to this sort of experience, one would certainly expect to be most true in the case of the equality judgments. We are in an extremely interesting position for the giving of definite evidence on this question, inasmuch as Wood's experiment in the analysis of the process of recognizing was carried on in this same laboratory partly simultaneously with our own experiments.[8] Indeed Observers *F.*, *Fs.*, and *W.* took part in both experiments and Dr. Woods (*Wd.*) was herself an observer in our investigation. It is doubtful if such an opportunity for comparing two related processes has ever occurred in the literature, the analyses being made in the same laboratory, partly simultaneously and in part with the same group of subjects. We may say, briefly but most definitely, that the process of comparing is by no means to be confounded with the process of recognizing. From the purely structural side, the results of the two investigations are in entire agreement; inasmuch as sensations, images and affections proved to be the elemental experiences in both cases. But the "pattern" of these experiences in consciousness differs very greatly for the processes of recognizing and of comparing as described by the observers in the two investigations.

Finally the protocols of our observers bear upon one other point. It has been found statistically that when two stimuli are exposed simultaneously, but obviously in different spatial arrangement, that there is a movement of the point of subjective equality.

[8] E. L. Woods, An Experimental Analysis of the Process of Recognizing. *Amer. Jour. of Psychol.*, XXVI, 1915, 313-387.

The term "space error" has been applied to this group of facts. In the case of weights lifted simultaneously, this may be due to differences in sensitivity in the two hands. But in the case of an arrangement such as the comparing of visual extents in our experiments, the facts are capable of a very different interpretation. Because two stimuli are *exposed* simultaneously there is no guarantee that they will be *perceived* simultaneously. Indeed the reports of our observers show, with this particular arrangement which we employed, that the two stimuli were almost always perceived successively. Hence it would seem that we are here dealing, not with a space error in the true sense of the word, but really with a form of time error. The presence of a time error would obviously be explained in the usual manner,—namely that the imaginal or kinaesthetic representation of the standard stimulus has a tendency to decrease in intensity, and hence leads to an overestimation of the comparison stimulus.

VI. *Conclusions*

1. The structural components of the process of comparing we found to be primarily sensations and images. At first there was a tendency for the image to be present in consciousness to a much greater extent than the sensation, but with practice these relations tended to be reversed. Affections were infrequently reported. Affections do not seem to be an essential part of the process of comparing but seem, rather, to be bound up with the degree of subjective assurance for the observer.

2. The attributive pattern of the process of comparing varies to a certain extent with the materials presented, with the particular subject and with the stage of practice in which we find the subject. At least three stages of practice are to be observed, with a more or less typical kind of process for each.

a. With early practice the process consisted essentially in a rapidly successive and focal awareness of an imaginal representation of the standard stimulus with a perception of the comparison stimulus. This imaginal representation of the standard stimulus was at first relatively complex; consisting of images of several modalities, although almost invariably kinaesthetic images were present no matter what the modality of the stimulus. Gradually this kinaesthetic experience was described as a sensation and not as an image.

b. In the second stage, the process of comparing consisted essentially in a perception of the standard stimulus followed by a focal kinaesthetic reaction. This reaction was then retained as an actually innervated muscular set. The comparison stimulus was then perceived in the presence of this set and the subject was then aware either of an increase, decrease, or of a persistence (no change) in this set. These experiences led to the formation of the "greater," "less" and "equality" judgments respectively. Such a process was most frequently reported for our experiments with lifted weights, visual extents and sound intensities as stimuli. Another form of process, reported at this stage of practice, consisted essentially in the formation of an absolute judgment on each of the two stimuli. This absolute judgment seemed to be largely an immediate perceptual experience, with either vocal-motor characterization or the use of a visual imaginal schema. Such a process was most frequently reported for the comparing of visual brightnesses.

c. In the case of our series of the comparing of visual extents, a third stage was reached by several of our subjects due to continued practice. In the process of comparing at this stage we found merely a perception of the comparison stimulus directly, in the presence of a kinaesthetic set carried over from the pair of lines which had been exposed just before. The observer was then aware of an increase, decrease or persistence of this kinaesthetic set. In such a procedure the standard stimulus was never perceived at all. It is obvious that this third stage can only be reached in those arrangements where the two stimuli are presented simultaneously, inasmuch as in the successive presentation the awareness of the standard stimulus fills consciousness for a time.

3. We find certain differences between the processes which led to the formation of the equality and difference judgments in the case of most of our observers. In the case of the difference judgments there was immediate vocalization and the process was completed. In the case of the equality judgments, there was usually a verification process between the initial formulation of the judgment and the vocalization. This verification process, which consisted essentially in a perceptual or an imaginal alternation of the two stimuli, was very frequently accompanied by unpleasantness and general bodily strains. This general attitude of doubt is probably due to the negative character of the equality judgment, inasmuch as the subject has assumed the attitude of looking for a difference. This latter had been developed, we believe, because in the experiences involving a kinaesthetic set, the observer was more easily and focally aware of an increase or decrease in the intensity of the muscular contraction than he was of a mere awareness of a muscular strain. In those experiences which consisted essentially of the formation of absolute judg-

ments and not involving the kinaesthetic set, there was seldom any difference between the character of the processes which led to the formation of the equality and difference judgments.

4. The concept of the process of comparing, which consists essentially in the awareness of a change or persistence of an actually innervated muscular set, is capable of explaining several groups of facts which have been discovered statistically for the practiced subject. Among these are the effects of progressive practice, the effects of mental and physical work in the formation of judgments in lifted weight experiments, and the formation of the attitude of looking for a difference in the performing of a psychophysical experiment.

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